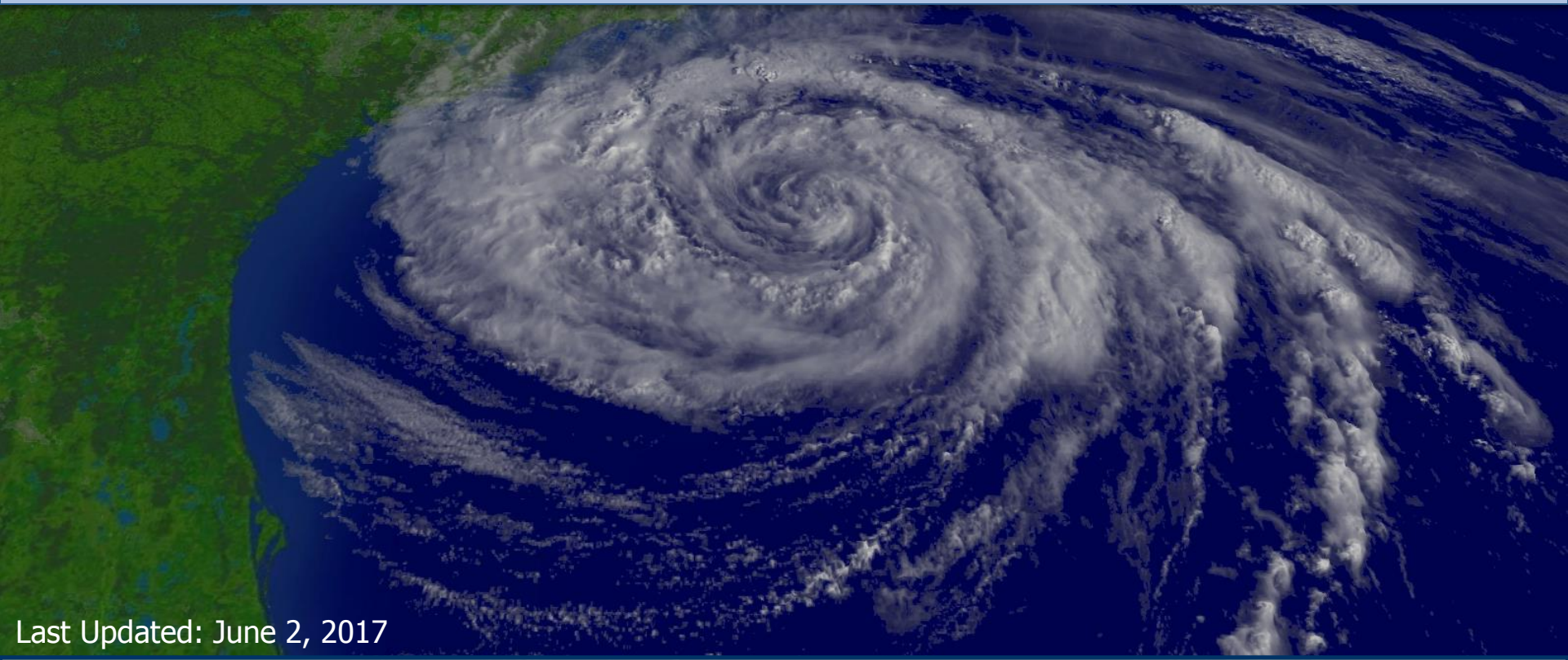
2017 Hurricane Guide for Southeast South Carolina/Georgia

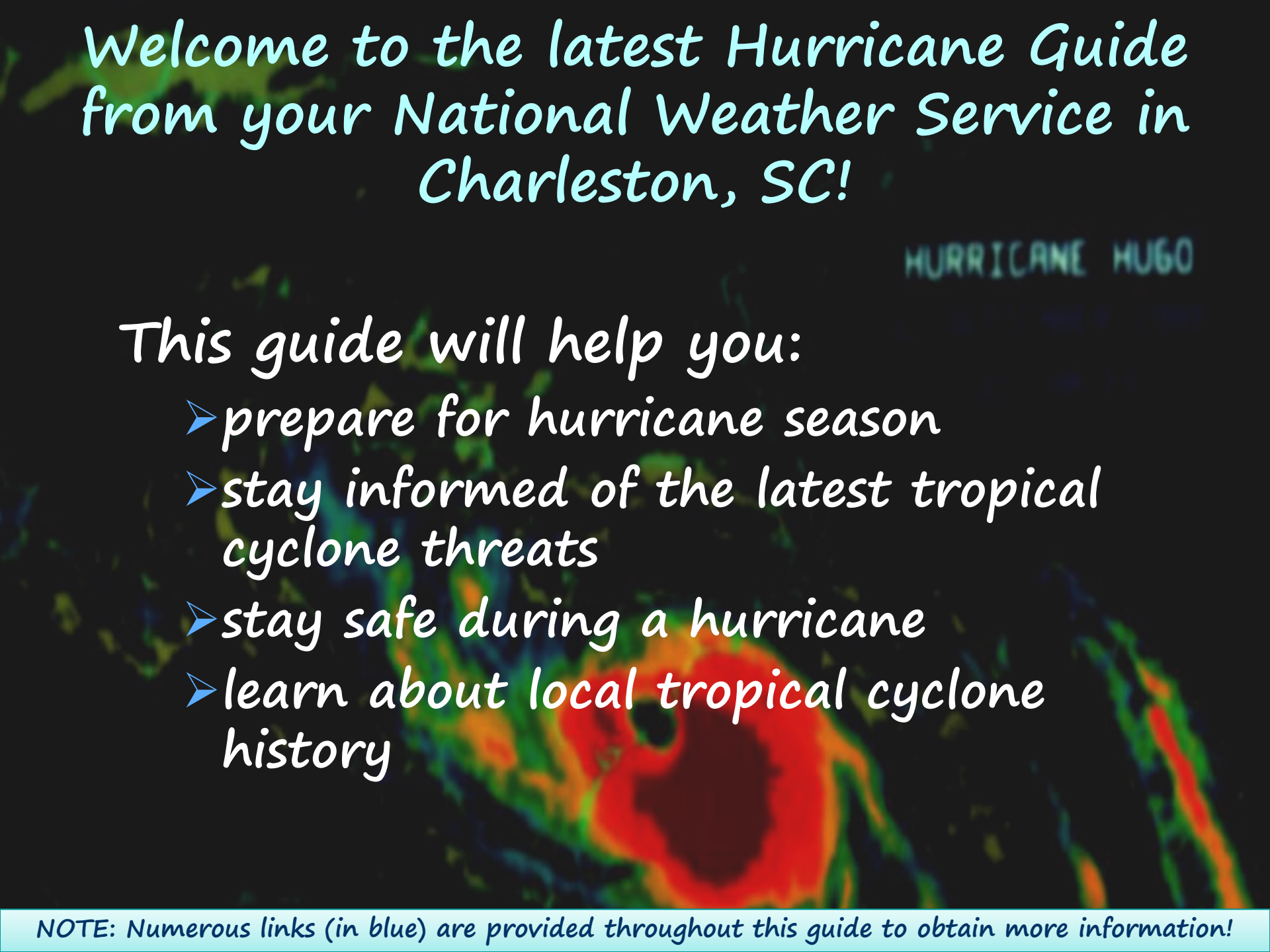
Plan, Act, Survive!



Last Updated: June 2, 2017

National Weather Service
Charleston, SC
weather.gov/chs

Welcome to the latest Hurricane Guide from your National Weather Service in Charleston, SC!



This guide will help you:

- prepare for hurricane season
- stay informed of the latest tropical cyclone threats
- stay safe during a hurricane
- learn about local tropical cyclone history

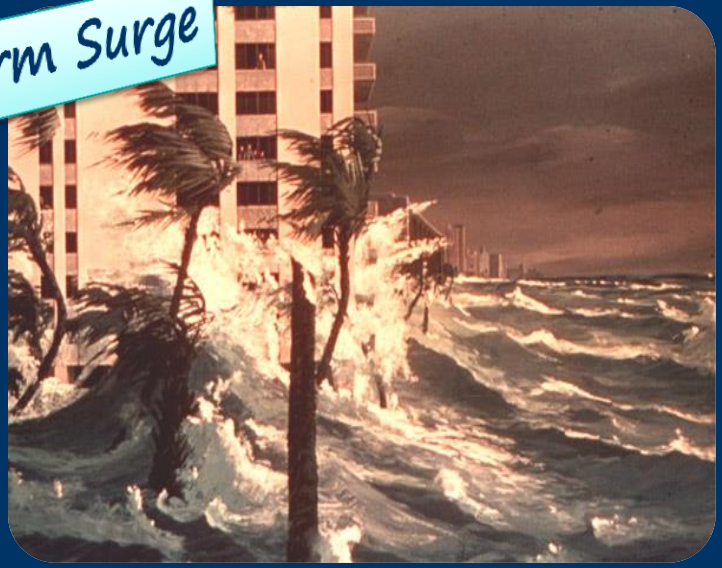
NOTE: Numerous links (in blue) are provided throughout this guide to obtain more information!

Outline

- **Tropical Cyclone Hazards**
- Being Prepared and Staying Informed
- Tropical Cyclone Basics
- Tropical Cyclone Climatology
- Tropical Cyclone History for Southeast South Carolina and Southeast Georgia

Main Tropical Cyclone Hazards

Storm Surge



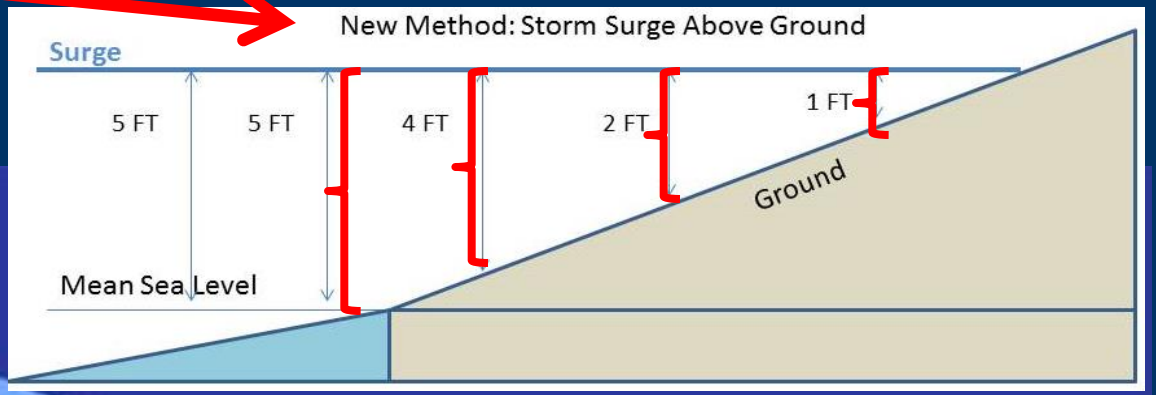
High Winds

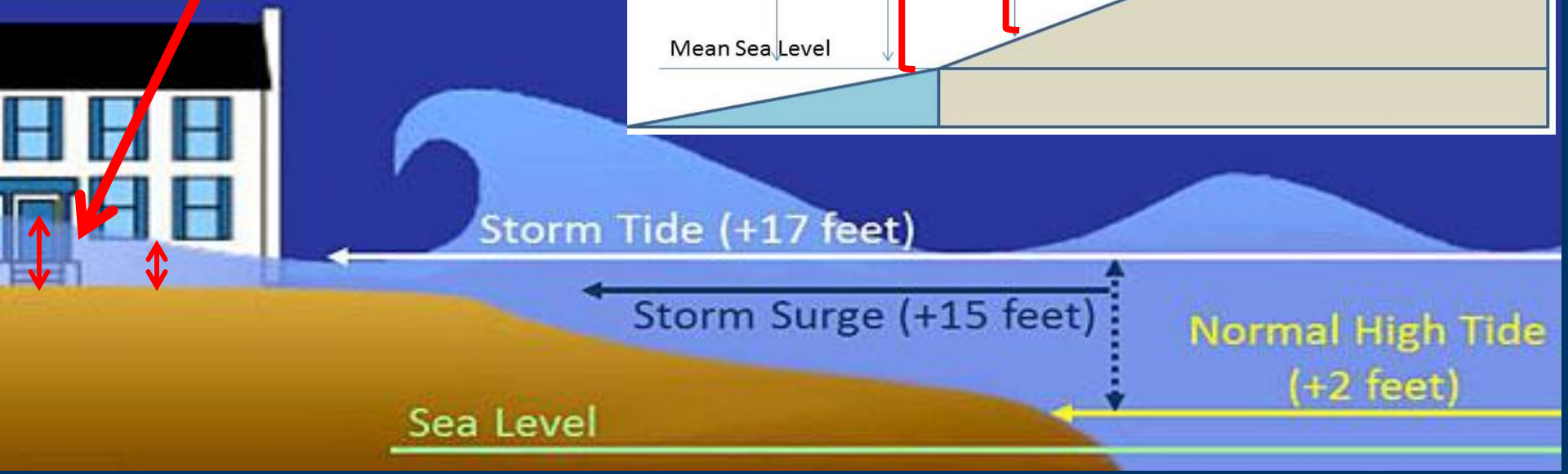
Tornadoes/Waterspouts

Flooding Rains

Storm Surge Terminology

- **Storm surge:** abnormal rise of water generated by a storm
- **Storm tide:** storm surge + astronomical tide
- **Inundation: height/depth of water above the ground**

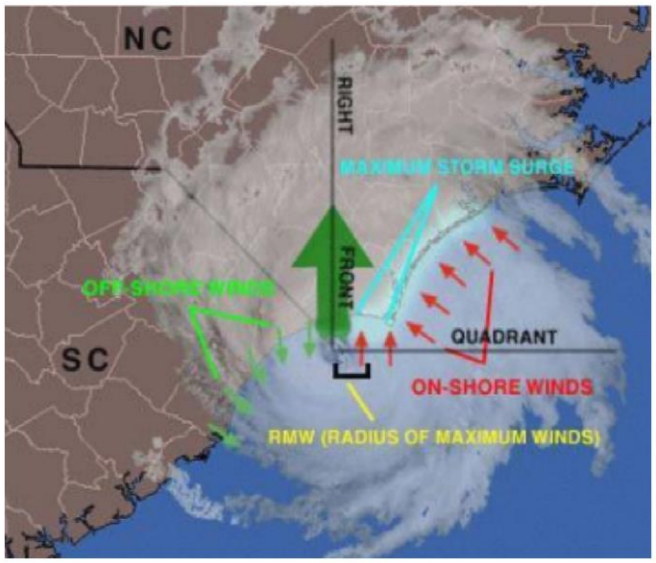




Storm Surge Facts

- Greatest threat to life and property along the coast
- **Can occur rapidly and forcefully and travel many miles inland in low-lying areas (such as along the SC/GA coasts)**
- Produced mainly by strong winds blowing over the ocean for an extended period
- Stronger, larger and faster storms generally produce higher surge
- The amount of surge is not solely dependent on the storm category
- Highest surges at the coast typically occur to the right of where the center of the storm comes ashore (blue area outlined in the image to the right)

Isle of Palms, SC after Hurricane Hugo (1989)



« Images courtesy of NWS

Storm Surge Facts

- There will be more flooding if the highest surge occurs around high astronomical tide (compared to low tide)
- The coastal areas of SC/GA are very surge-prone given the low elevation and gently sloping continental shelf offshore
- In 1989, Hurricane Hugo produced the highest water levels ever recorded on the U.S. East Coast (~20 foot storm tide above Mean Sea Level at Bulls Bay, SC and ~10 foot storm tide above MSL in downtown Charleston, SC)

« *Images courtesy of NWS*

Romain Retreat, SC (near Bulls Bay) after Hugo

Edisto Beach, SC after Matthew

Storm Surge Impacts

Folly Beach, SC – before Hugo

Folly Beach, SC – after Hugo

Hurricane Ivan (2004):
- Category 3; 10-16 foot surge

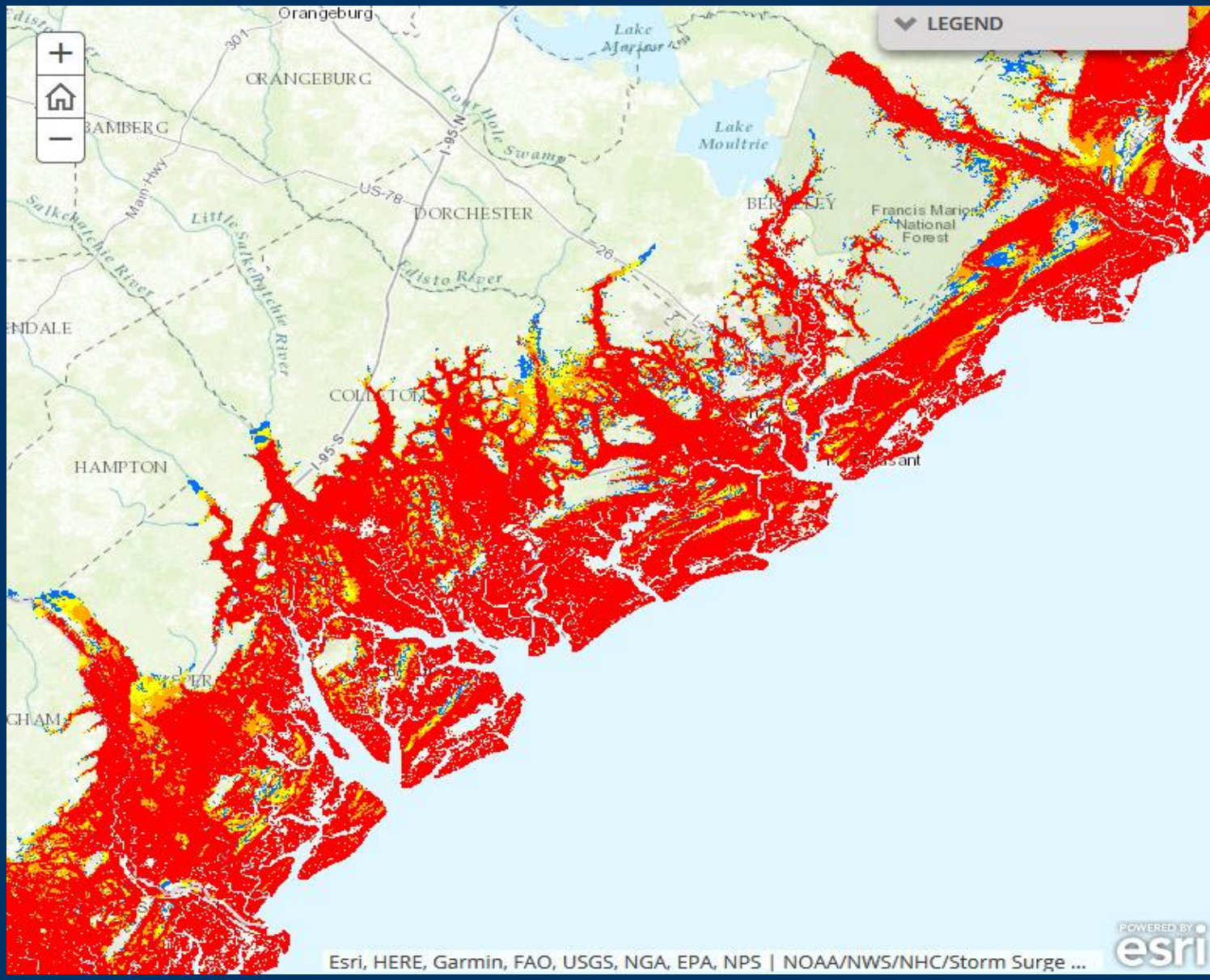
Hurricane Ike (2008):
- Category 2
- 15-20 foot surge

« Images courtesy of NWS

Local Storm Surge Risk

Southern South Carolina Coast

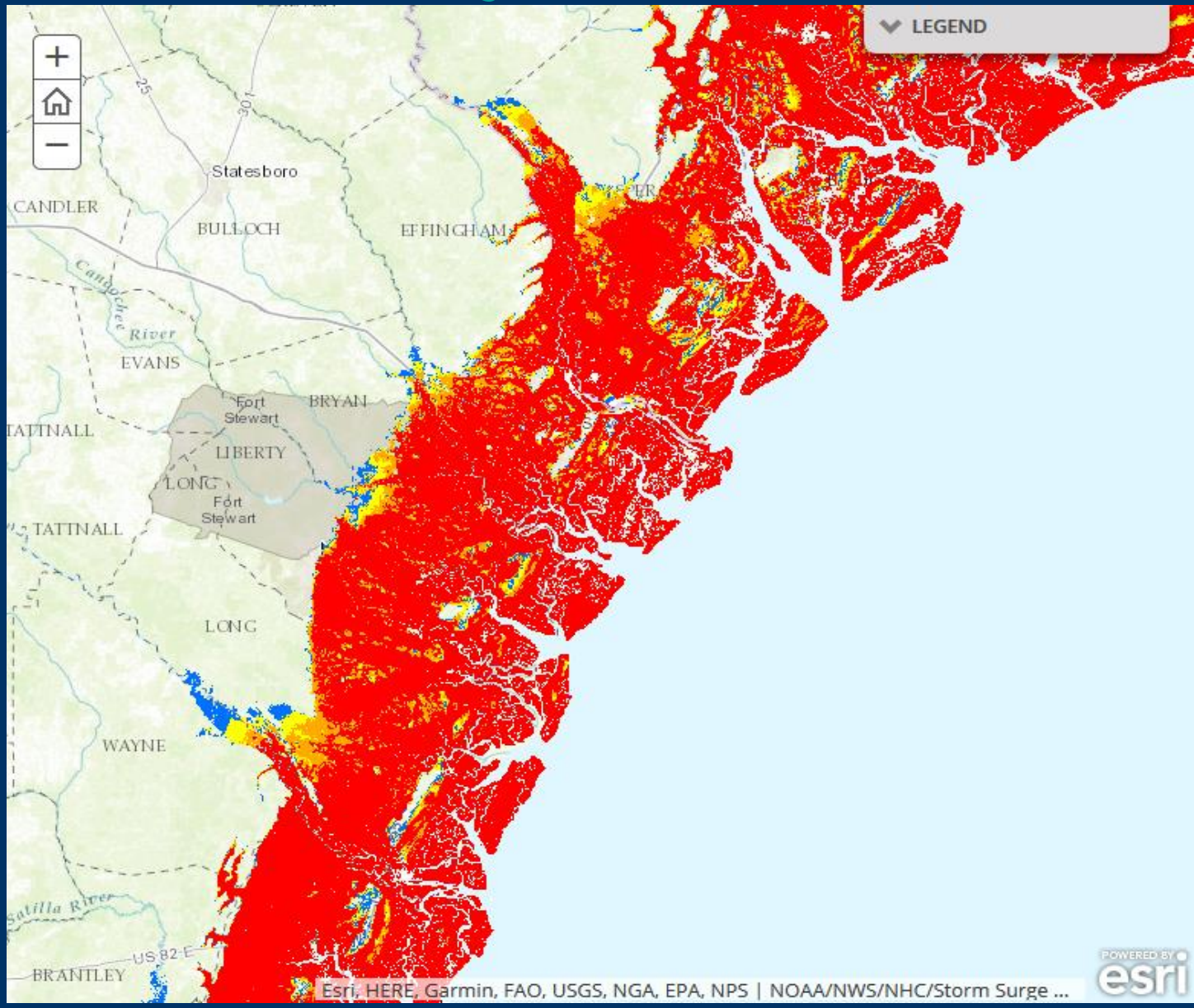
Approximation of the "worst case" inundation (i.e., amount of water above ground) for a hurricane in this area. Note how far inland the storm tide can reach…mainly along low-lying rivers and creeks. Usually the worst inundation at any location will occur if the storm comes ashore south of that area.



Local Storm Surge Risk

Northern Georgia Coast

Approximation of the "worst case" inundation (i.e., amount of water above ground) for a hurricane in this area. Note how far inland the storm tide can reach, mainly near rivers and creeks. **Usually the worst inundation at any location will occur if the storm comes ashore south of that area.**



Are You At Risk From Storm Surge?

- If you live in/near any of the shaded areas on the maps on the previous 2 slides you are vulnerable to storm surge!
- Check out NOAA's storm surge hazard maps
- Determine whether you are in an evacuation zone… SC / GA
- **Evacuate if advised to do so by local authorities!**
- Keep in mind that if you don't evacuate, your location may become an "island" cut off from emergency officials

High Winds

- Strong, damaging winds can occur hundreds of miles from the coast
- In fact, Hurricane Hugo in 1989 produced hurricane force wind gusts in Charlotte, NC toppling numerous trees and power lines (see image to the left below)

« Images courtesy of NWS

High Wind Facts

- Generally the stronger the storm at landfall the longer it will take for the winds to diminish
- Coastal areas/high-rise buildings:
  - winds normally higher due to less surface friction
- Inland areas away from the immediate coast:
  - sustained winds generally lower than at coast, but gusts can be similar to sustained winds at coast

« Images courtesy of NWS

Charleston Area After Hurricane Hugo (1989)

High Wind Safety

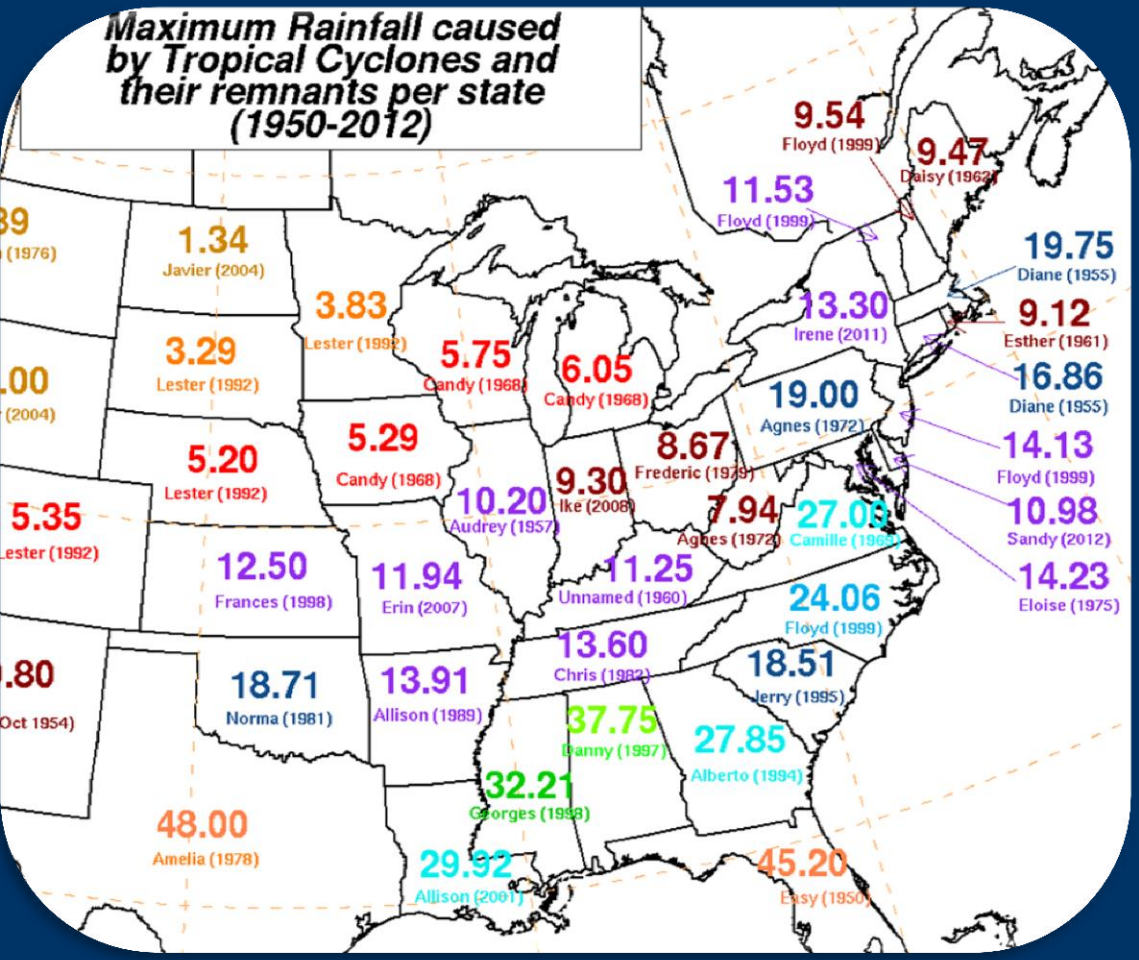
- Cover all windows and doors with plywood or shutters
  - Do NOT leave any windows/doors open to relieve pressure
  - Tape does NOT work!
- Reinforce garage doors as they are typically weak points
- Store all outdoor items that could become deadly missiles
- Evacuate to a more sturdy structure if you live in a mobile/manufactured home, especially if advised to do so by local authorities
- During a storm, go to your "safe place" which should be the most interior room on the lowest floor of your building that is not prone to flooding and protect your head with helmets or pillows

Flooding Rainfall

- **When you think "hurricane", think "flooding"!**
- Most deaths in more recent tropical cyclones have been from inland fresh water flooding
- Weak storms can still produce a lot of rainfall
- Slower storms can produce more rainfall
- Determine whether you live in a flood zone and evacuate if advised to do so by local officials
- Never drive through flooded roads since you don't know how deep the water is and the road may be washed out

Remember, it only takes ~1 foot of water to move most small vehicles!!

Flooding Rainfall



« *Images courtesy of NWS/Weather Prediction Center (left) and WTOC-TV (right)*

- The coastal areas of SC and GA, particularly in urban areas like downtown Charleston and Savannah, are particularly vulnerable to flooding given the added influence of the storm tides

Tornadoes/Waterspouts

- Typically short-lived (minutes) and weak (EF0-EF1: up to 110 mph), although can be much stronger
- Typically occur within the storm's outer rain bands and near the center (eye wall)
- During the storm, if the NWS issues a "Tornado Warning" or "Extreme Wind Warning" for your location, go to your "safe place" (i.e., most interior room on lowest floor not prone to flooding)

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Before the Storm…

- Determine your elevation and whether you live in a flood zone (i.e., if you are vulnerable to flooding from storm surge)
  - If you live in/near any of the shaded areas on the surge maps found earlier in this guide you are vulnerable to storm surge!
  - Refer to your county emergency management office… SC / GA
- Learn which pre-designated evacuation zone you live in… SC / GA
- If you are evacuating, find a hotel/shelter and learn evacuation routes
- Get a disaster supply kit that includes sufficient food and water
- Prepare your home by boarding up windows/doors with plywood and trimming trees and shrubbery
- Review your insurance policy (Note: flooding is not covered and must be purchased via the National Flood Insurance Program for which there is roughly a 30 day waiting period)
- Make plans for your pets since some shelters/hotels do not accept them

Remember…preparation is key!

If evacuating...leave early!!

Motorists Trapped on I-26 During Hurricane Floyd (1999)

An average size car will flip in 115 mph winds!

Watch/Warning Definitions

Watch/Warning	What?	When?
Tropical Storm Watch	Sustained tropical storm force winds (39-73 mph) are *possible*	Within ~48 hours
Hurricane Watch	Sustained hurricane force winds (74+ mph) are *possible*	Within ~48 hours
Storm Surge Watch	Life-threatening inundation (3+ feet above ground) is *possible*	Within ~48 hours
Tropical Storm Warning	Sustained tropical storm force winds (39-73 mph) are *expected*	Within ~36 hours
Hurricane Warning	Sustained hurricane force winds (74+ mph) are *expected*	Within ~36 hours
Storm Surge Warning	Life-threatening inundation (3+ feet above ground) is *expected*	Within ~36 hours

If a Watch is Issued For Your Area…

- Determine if you are vulnerable to storm surge flooding
- Learn your pre-designated evacuation zone as well as official evacuation routes… SC / GA
- Evacuate if you are advised to do so by officials, and do so early!
- If evacuating, notify your friends/family and note that some shelters/hotels do not accept pets
- Review your disaster plan and check your supply kit
- Prepare your home by trimming weak/dead branches, covering windows/doors and bringing in unsecured outdoor items
- Inspect/secure mobile home tie downs
- Gas your vehicles and get cash since ATMs won't work w/o power
- Store drinking water in jugs, bottles and clean bathtubs (at least 1 gallon per person per day for 3 days)

If a Warning is Issued For Your Area…

- **Rush protective actions to completion!!**

- Evacuate as soon as possible, especially if advised to do so by authorities!
  - Notify friends/family of where you are going
  - Take your disaster supply kit with you
  - Unplug appliances and turn off electricity/main water valve

- If not evacuating…
  - Be sure you are not vulnerable to storm surge flooding
  - Ready your disaster supply kit
  - Turn your refrigerator/freezer to their coldest settings and keep closed as much as possible
  - Cover windows/doors and store unsecured outdoor items
  - Fill bathtubs and large containers with water for cleaning/flushing purposes in case clean tap water becomes unavailable (at least 1 gallon per person per day for 3 days)
  - Inspect/secure mobile home tie downs
  - If power is lost, turn off major appliances to reduce power "surge" when electricity is restored

After the Storm…

- If you have evacuated, don't return home until notified by officials
- Watch for downed trees/power lines, glass, nails, and other debris as well as snakes, insects and other animals
- Don't drive through flooded roads
- Don't run power generators indoors
- Help neighbors, especially the elderly
- Be patient as help may take several days!
- More recovery tips…. http://www.ready.gov/recovering-disaster

« Images courtesy of NWS

Staying Informed:

Real-time Storm Information

- Social Media:
  - NWS Charleston Facebook: https://www.facebook.com/NWSCharlestonSC
  - NWS Charleston Twitter: @NWSCharlestonSC
- Mobile:
  - hurricanes.gov/mobile
- Internet:
  - NWS Charleston, SC: weather.gov/chs
  - National Hurricane Center: hurricanes.gov
- NOAA Weather Radio:
  - http://weather.gov/nwr
- Local TV/Radio

NWS Tropical Products/Services

National Hurricane Center

- Forecasts development, track, and strength of tropical cyclones

hurricanes.gov

NWS Charleston, SC

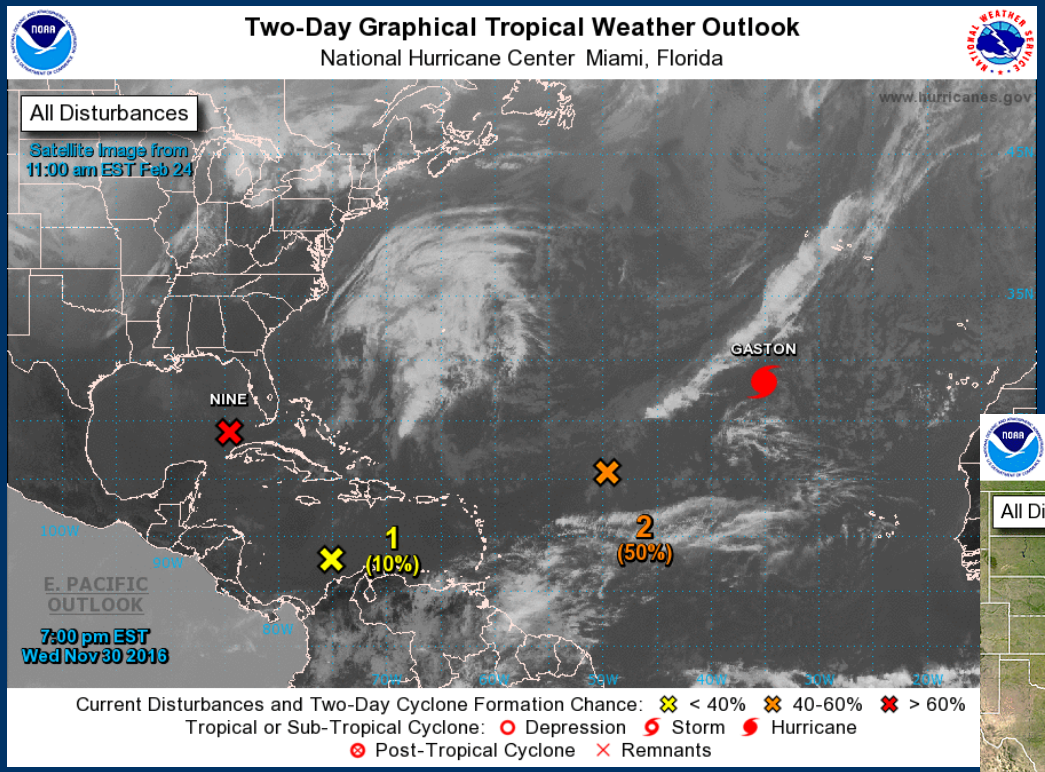
- Localizes the potential tropical cyclone impacts for Southeast SC/GA

weather.gov/chs

NHC Tropical Weather Outlook

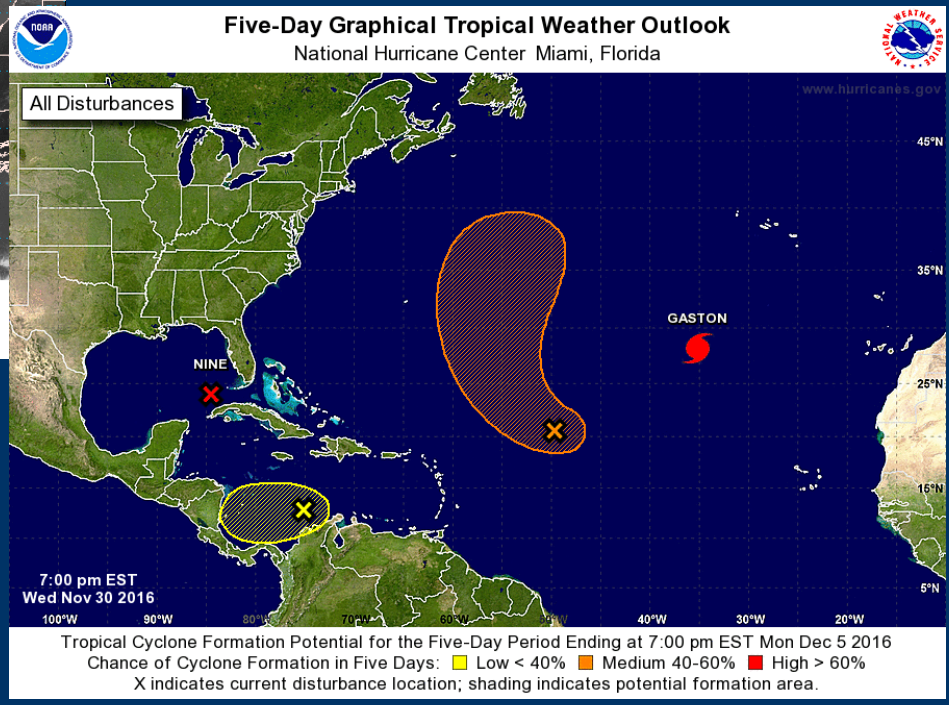
http://hurricanes.gov/gtwo_atl.shtml

- Shows current storms and areas of possible tropical cyclone formation



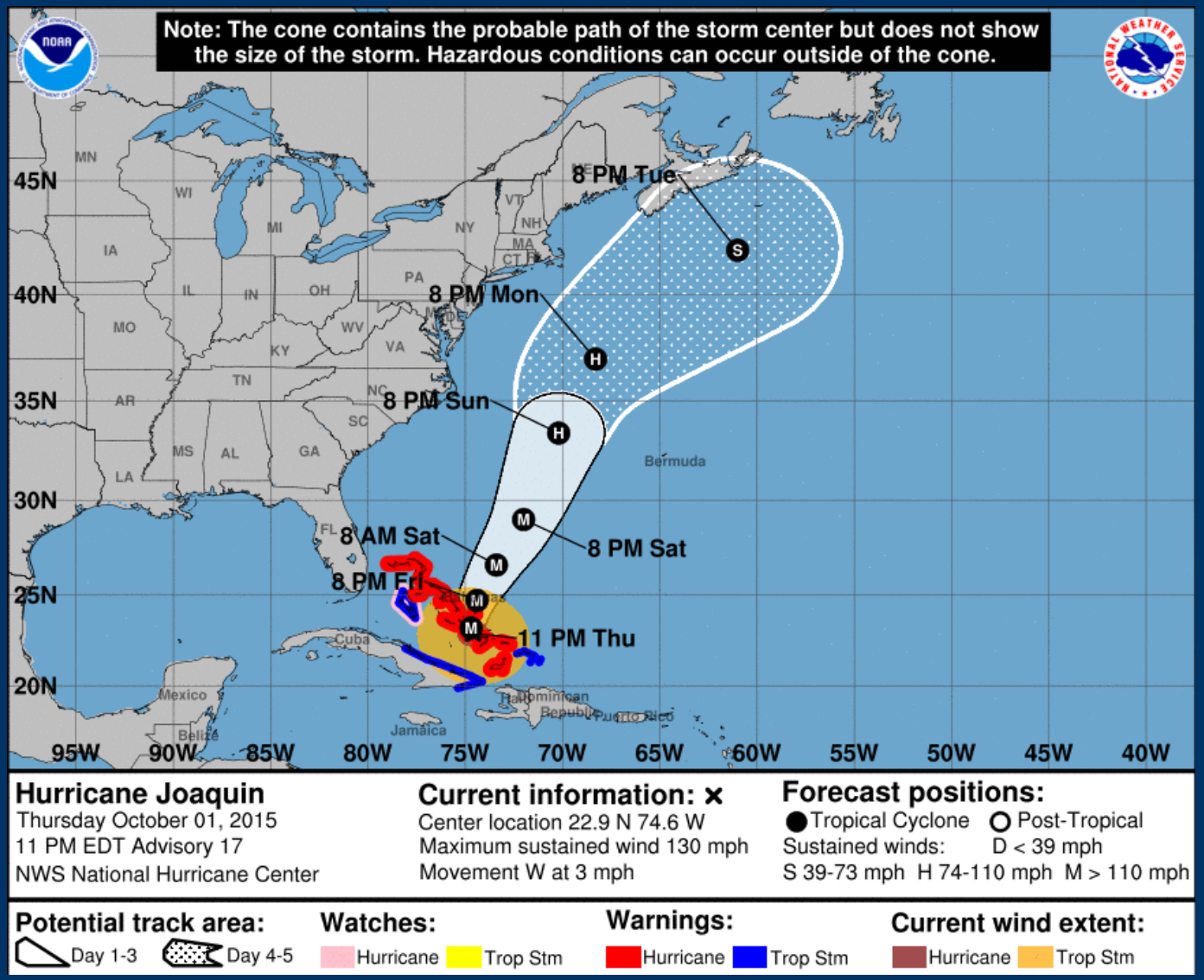
2-day Outlook

5-day Outlook



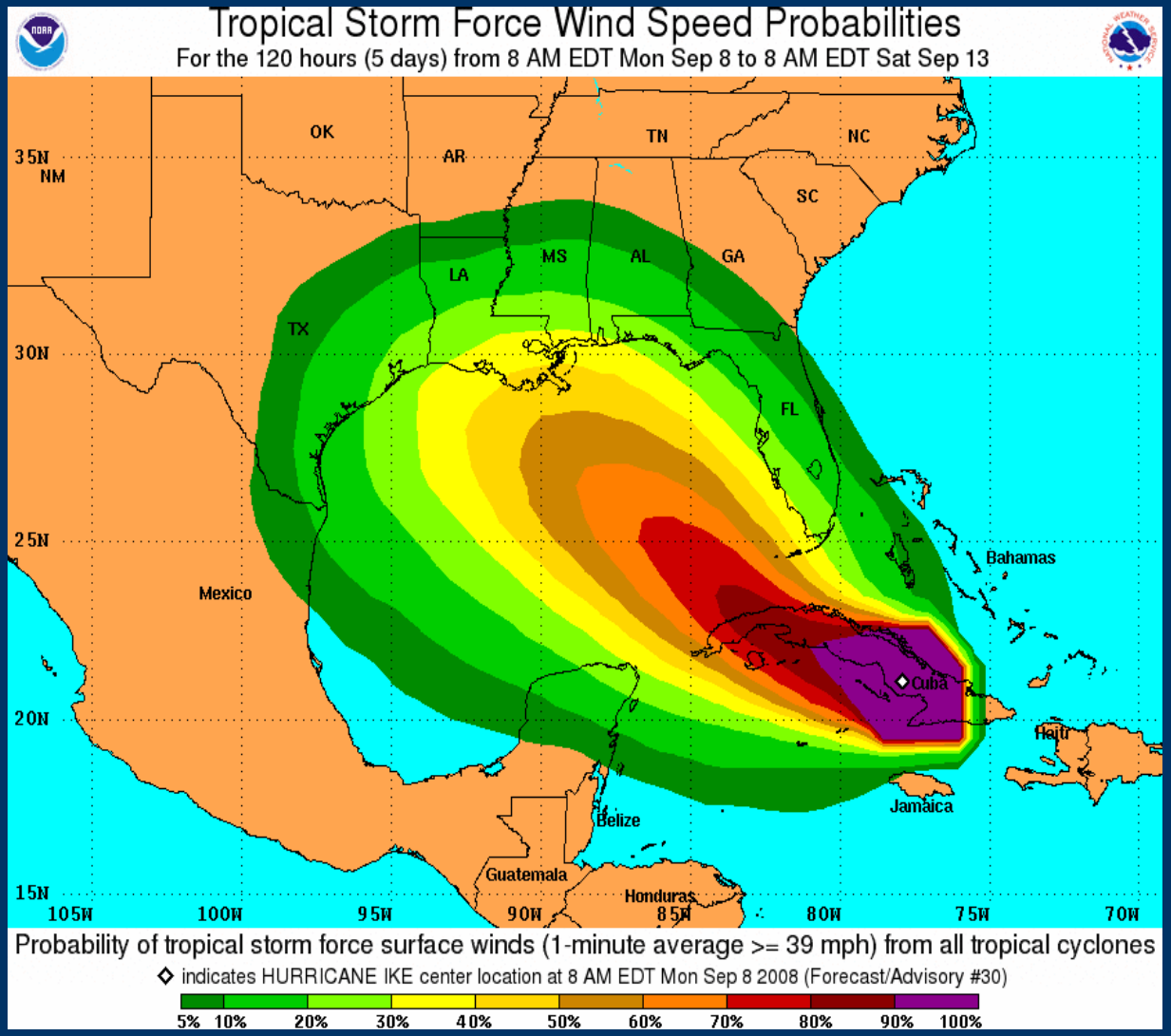
NHC Track Forecast Cone

- Shows the likely storm track along with the latest tropical storm/hurricane watches and warnings
- Can toggle on current wind field
- The "cone" does NOT indicate the area of possible impact, just the likely track of the storm center!



NHC Wind Speed Probabilities

- Shows the chance of 34 knot (tropical storm force), 50 knot, and 64 knot (hurricane force) winds through the next 5 days, as well as during particular time periods
- Accounts for uncertainty in the storm's track/size/intensity
- NOTE: Low probabilities do NOT necessarily imply low risk!
- Product description:
  - http://www.nhc.noaa.gov/aboutnhcgraphics.shtml#WINDPROB



- The graphic above shows the probabilities of tropical storm force winds during the next 5 days

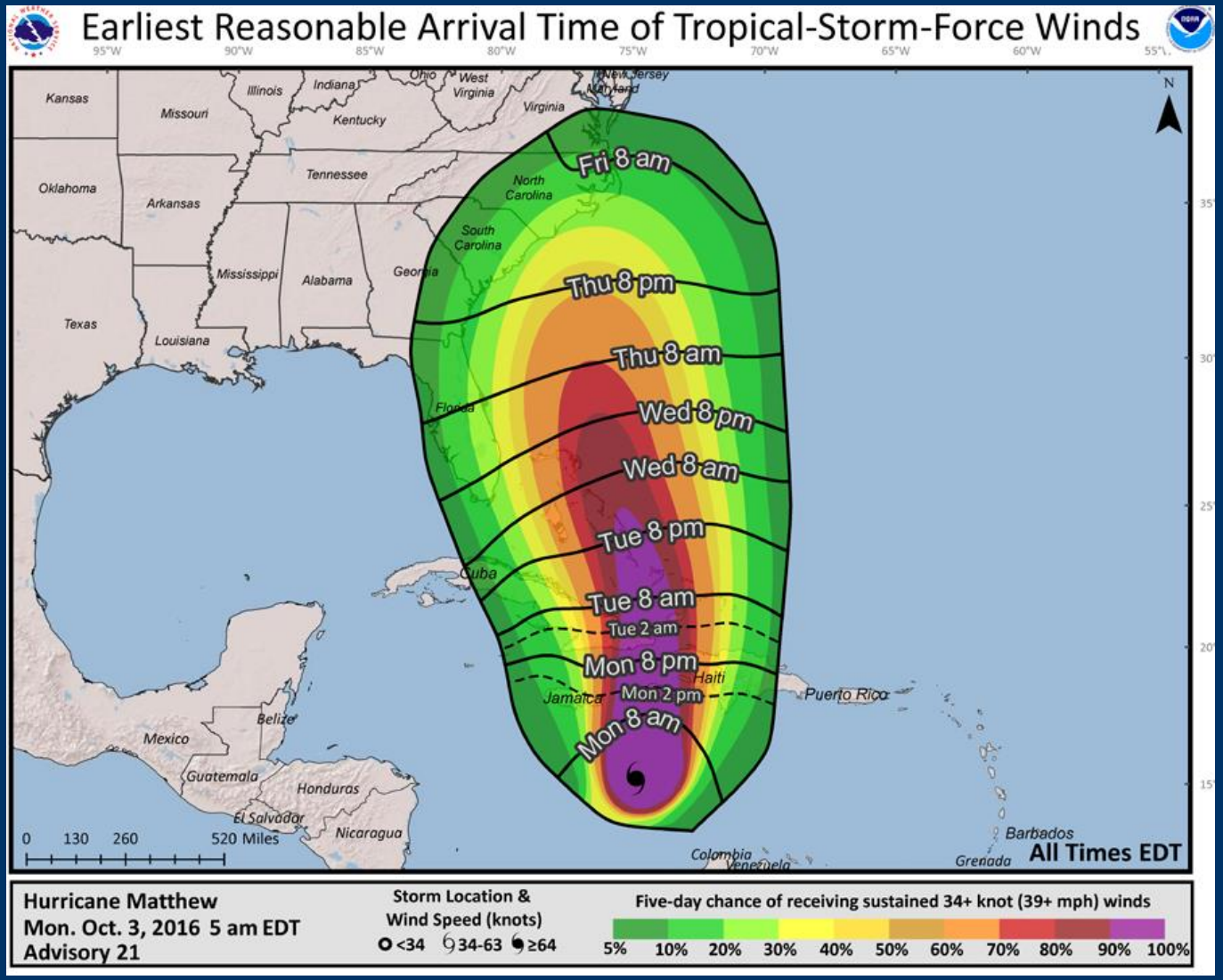
NHC Wind Speed Probabilities Example

Forecast Hour	12	24	36	48	72	96	120
CHARLOTTE NC	34 X	X(X)	X(X)	X(X)	1(1)	3(4)	3(7)
MOREHEAD CITY	34 X	X(X)	4(4)	6(10)	13(23)	4(27)	2(29)
MOREHEAD CITY	50 X	X(X)	X(X)	X(X)	4(4)	2(6)	X(6)
MOREHEAD CITY	64 X	X(X)	X(X)	X(X)	1(1)	1(2)	X(2)
WILMINGTON NC	34 X	X(X)	4(4)	4(8)	6(14)	4(18)	1(19)
WILMINGTON NC	50 X	X(X)	X(X)	X(X)	1(1)	1(2)	1(3)
WILMINGTON NC	64 X	X(X)	X(X)	X(X)	X(X)	1(1)	X(1)
COLUMBIA SC	34 X	X(X)	1(1)	X(1)	X(1)	2(3)	2(5)
MYRTLE BEACH	34 X	1(1)	3(4)	2(6)	4(10)	2(12)	1(13)
CHARLESTON SC	34 X	2(2)	3(5)	X(5)	1(6)	1(7)	1(8)
SAVANNAH GA	34 X	2(2)	2(4)	X(4)	X(4)	X(4)	1(5)

- The probability for tropical storm force winds (34 kt) at Savannah, Georgia in the 12-24 hour time period is 2%, the cumulative probability through 48 hours is 4% and the cumulative probability for the entire 5-day period (120 hours) is 5%.

NHC Wind Speed Time of Arrival Graphics

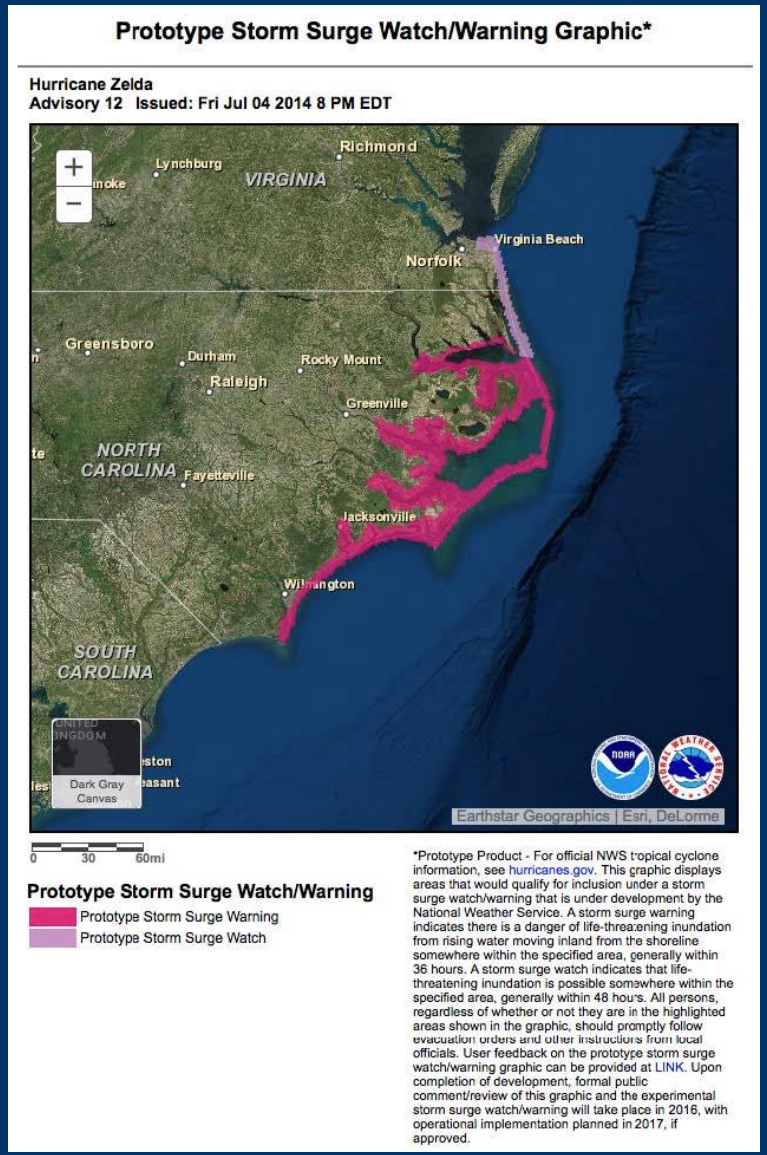
- Experimental graphics depicting the "earliest reasonable" arrival time of sustained TS-force winds (shown to the right; representing the time that has no more than a 10% chance of seeing the onset of sustained TS-force winds) and the "most likely" arrival time of sustained tropical storm-force winds (not shown; representing the time before or after which the onset of TS-force winds is equally likely)



NHC Storm Surge Watch/Warning

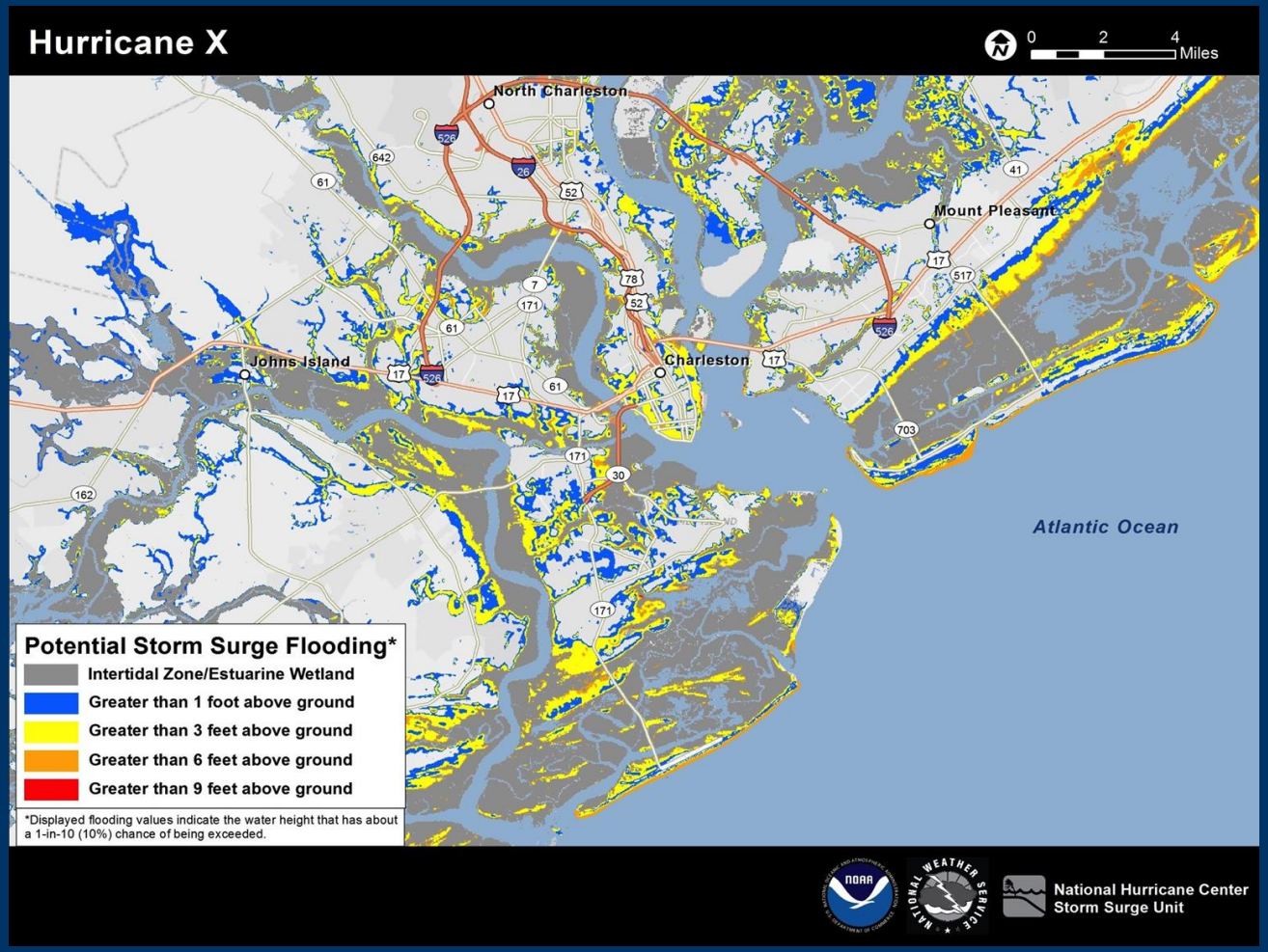
- Highlights areas that have a significant risk of life-threatening storm surge inundation from a hurricane (or tropical storm)
  - Watch: conditions possible within ~48 hours
  - Warning: conditions possible within ~36 hours
- Subjectively determined based on collaboration between the NHC and local WFOs
- Available on the NHC's website shortly after the Advisory is issued

http://hurricanes.gov/experimental/surgewarning/



NHC Potential Storm Surge Flooding Map

- Shows <u>potential</u> inundation (i.e., water heights above ground) that could result from a storm's surge combined with the astronomical tide (i.e., storm tide)
- Available on the NHC's website ~60-90 minutes after the 1st Hurricane Watch is issued for a storm (sometimes with a Tropical Storm Watch) and updated with each subsequent advisory
- Represents a plausible worst-case scenario and thus what people should prepare for



http://hurricanes.gov/surge/inundation/

NWS Charleston Products

Hurricane Local Statement (HLS)

HURRICANE MATTHEW LOCAL STATEMENT INTERMEDIATE ADVISORY NUMBER 35A
NATIONAL WEATHER SERVICE CHARLESTON SC AL142016
807 PM EDT THU OCT 6 2016

THIS PRODUCT COVERS SOUTHEAST SOUTH CAROLINA AND SOUTHEAST GEORGIA

****DANGEROUS HURRICANE MATTHEW WILL IMPACT THE REGION FRIDAY INTO SATURDAY****

NEW INFORMATION

*** CHANGES TO WATCHES AND WARNINGS:**
....
*** CURRENT WATCHES AND WARNINGS:**
....
*** STORM INFORMATION:**
.....
SITUATION OVERVIEW

....
POTENTIAL IMPACTS

*** WIND:**
...
*** SURGE:**
...
*** FLOODING RAIN:**
...
*** TORNADOES:**
...
PRECAUTIONARY/PREPAREDNESS ACTIONS

...
*** ADDITIONAL SOURCES OF INFORMATION:**
...
NEXT UPDATE

...

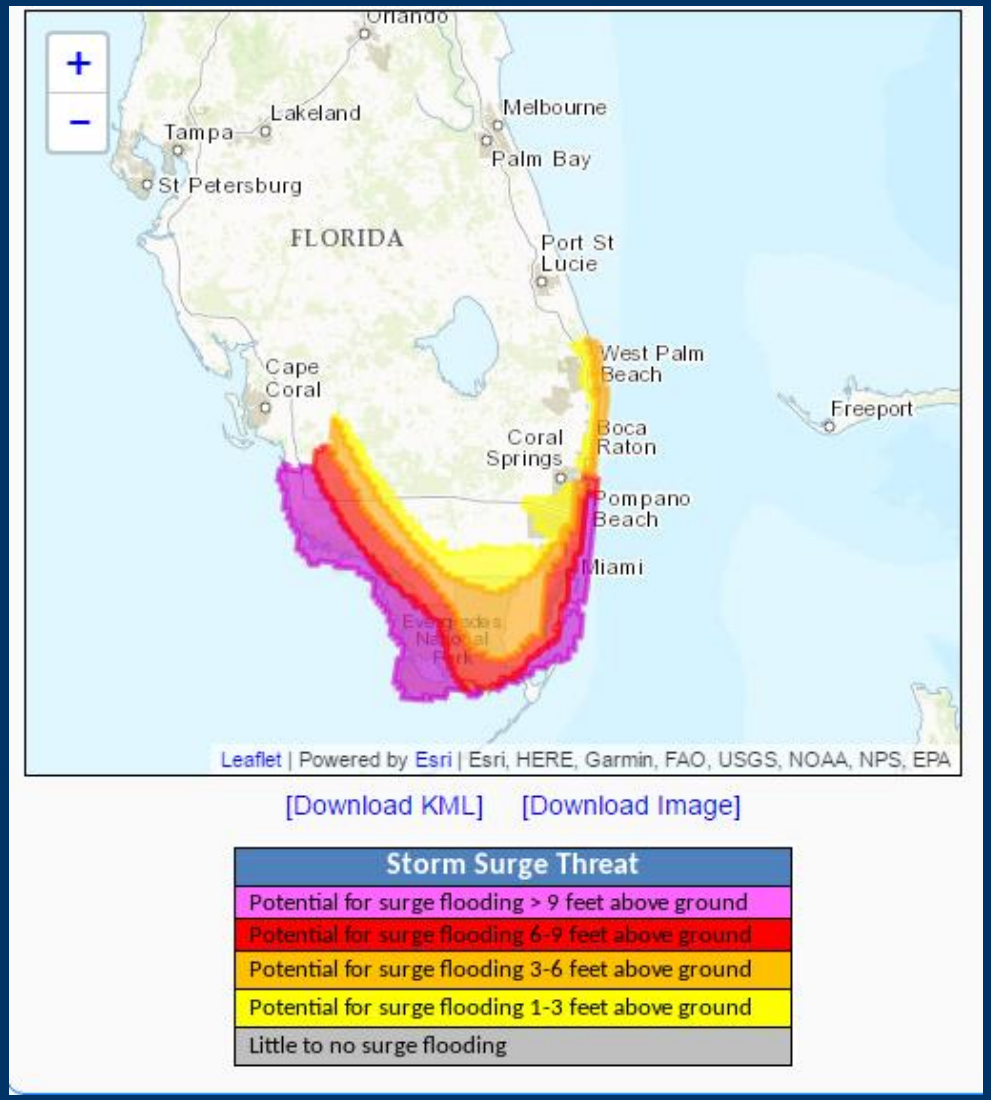
- Overview of the storm and its potential impacts across southeast SC/GA

« Portion of a HLS issued for Hurricane Matthew in 2016

NWS Charleston Products

Hurricane Threats and Impacts Graphics

- Shows the threat levels and potential impacts from wind, storm surge, rainfall and tornadoes that people should prepare for
- Provides recommended protective actions



NWS Charleston Products

Post-storm Report (PSH)

POST TROPICAL CYCLONE REPORT...TROPICAL STORM ANDREA...UPDATED
NATIONAL WEATHER SERVICE CHARLESTON SC
1009 AM EDT FRI JUN 14 2013

NOTE: THE DATA SHOWN HERE ARE PRELIMINARY....AND SUBJECT TO UPDATES AND CORRECTIONS AS APPROPRIATE.

THIS REPORT INCLUDES EVENTS OCCURRING WHEN WATCHES AND/OR WARNINGS WERE IN EFFECT...OR WHEN SIGNIFICANT FLOODING ASSOCIATED WITH ANDREA OR ITS REMNANTS WAS AFFECTING THE AREA.

COUNTIES INCLUDED...CHARLESTON...BERKELEY...COLLETON...BEAUFORT... BRYAN...LIBERTY...MCINTOSH...JASPER

JUN 14...UPDATED FOR...STORM SURGE/TIDE AND INLAND FLOODING.

A. LOWEST SEA LEVEL PRESSURE/MAXIMUM SUSTAINED WINDS AND PEAK GUSTS

METAR OBSERVATIONS...
NOTE: ANEMOMETER HEIGHT IS 10 METERS AND WIND AVERAGING IS 2 MINUTES

LOCATION ID	MIN	DATE/	MAX	DATE/	PEAK	DATE/
LAT LON	PRES	TIME	SUST	TIME	GUST	TIME
DEG DECIMAL	(MB)	(UTC)	(KT)	(UTC)	(KT)	(UTC)
KCHS-CHARLESTON INTL AIRPORT SC						
32.91 -80.03	999.4	07/0956	180/024	07/0956	180/034	07/0943
KSAV-SAVANNAH INTL AIRPORT GA						
32.12 -80.20	997.7	07/0753	270/016	07/1346	270/024	07/1346
KNBC-BEAUFORT MARINE CORPS AIR STATION SC						
32.48 -80.72	997.2	07/0856	250/016	07/1137	290/025	07/1608

- Summary of meteorological data and impacts across southeast SC/GA and the nearby Atlantic waters

« Portion of the PSH issued for Tropical Storm Andrea in 2013

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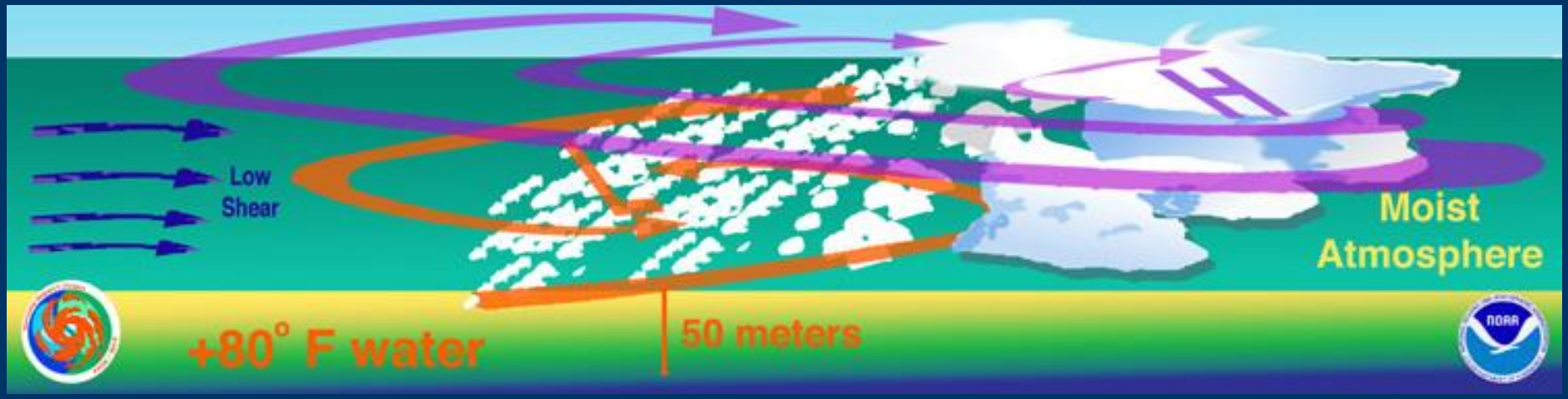
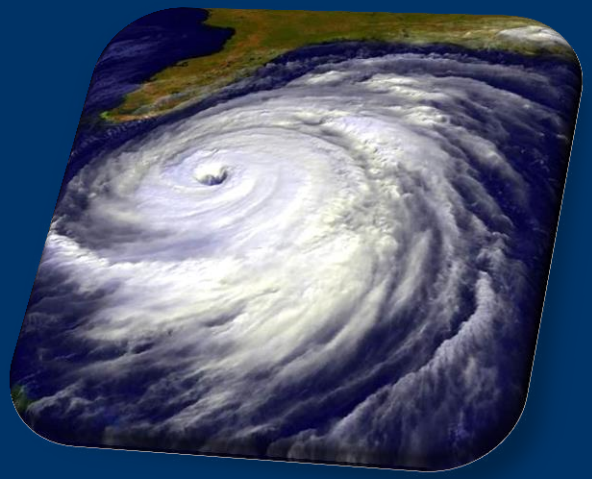
Tropical Cyclone Basics

- Tropical Cyclone: rotating system of showers and thunderstorms originating over tropical or subtropical waters and having a closed low-level circulation (i.e., at least one isobar around the center)
- Ingredients needed for development:
  - Ocean water temperatures 80 degrees Fahrenheit or greater
  - Low amounts of vertical wind shear (i.e., winds of different strengths/directions at different heights)
  - Moist and unstable air (i.e., air prone to rising)
  - Pre-existing near-surface low pressure with sufficient spin



Tropical Cyclone Stages

- Tropical Disturbance
- Tropical Depression
- Tropical Storm
- Hurricane



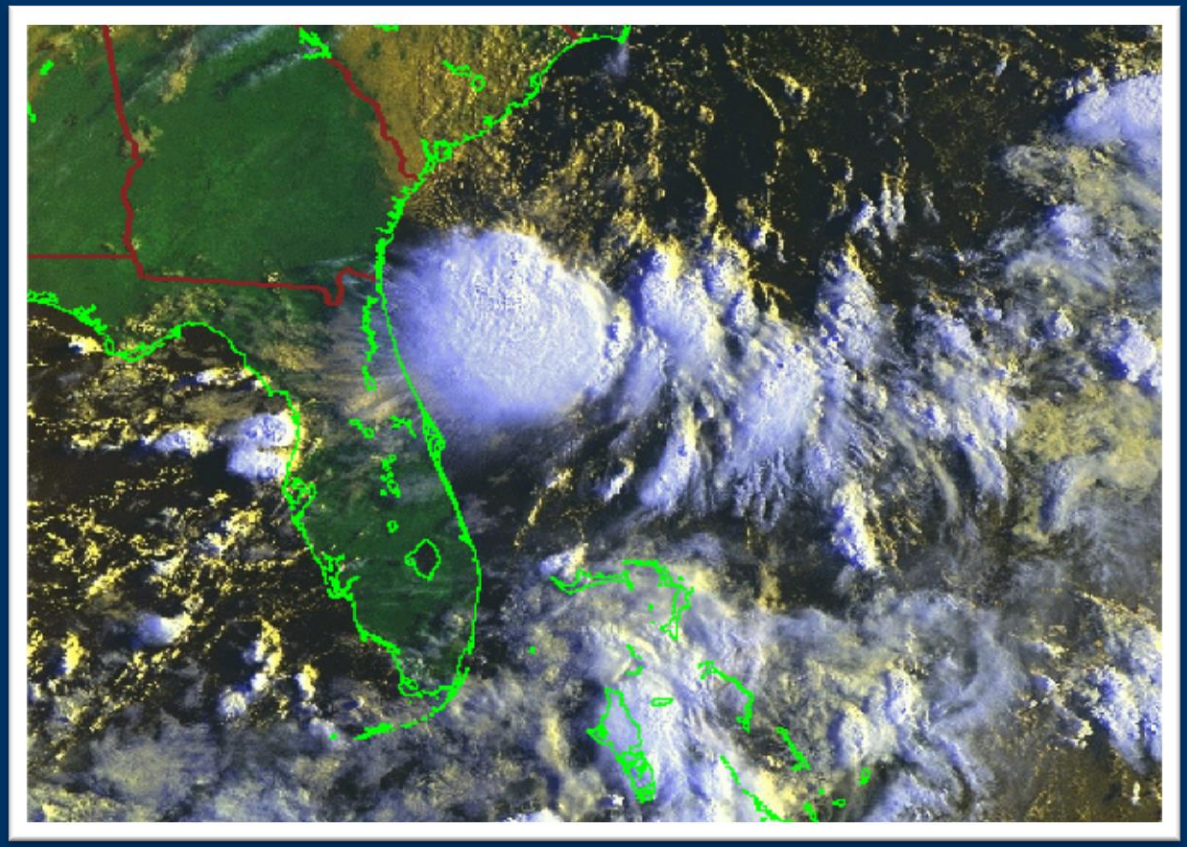
- Potential tropical cyclone: disturbance which has a high chance of becoming a tropical cyclone

- Post-tropical cyclone: former tropical cyclone which no longer possesses sufficient tropical characteristics but can still produce strong winds and heavy rain

Tropical Cyclone Stages

Tropical Disturbance

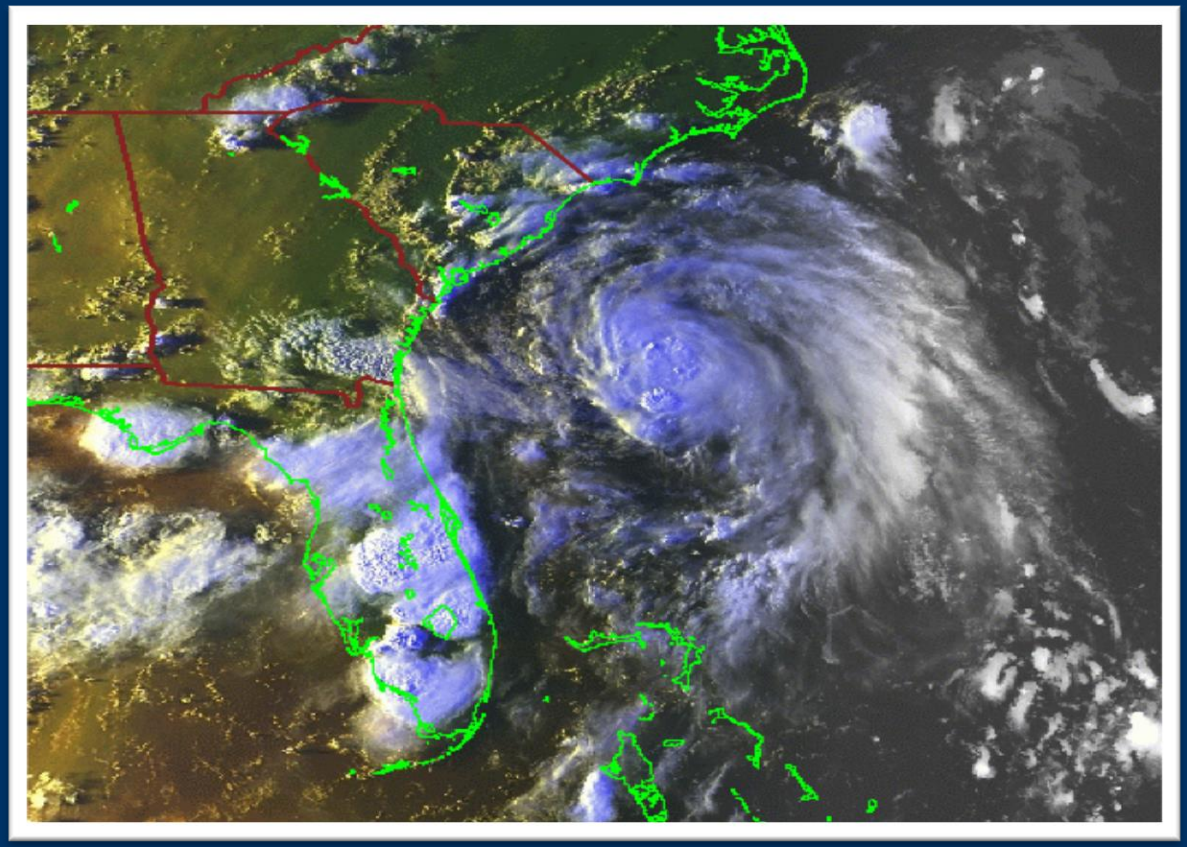
- no organized surface circulation
- disorganized cluster of thunderstorms



Tropical Cyclone Stages

Tropical Depression

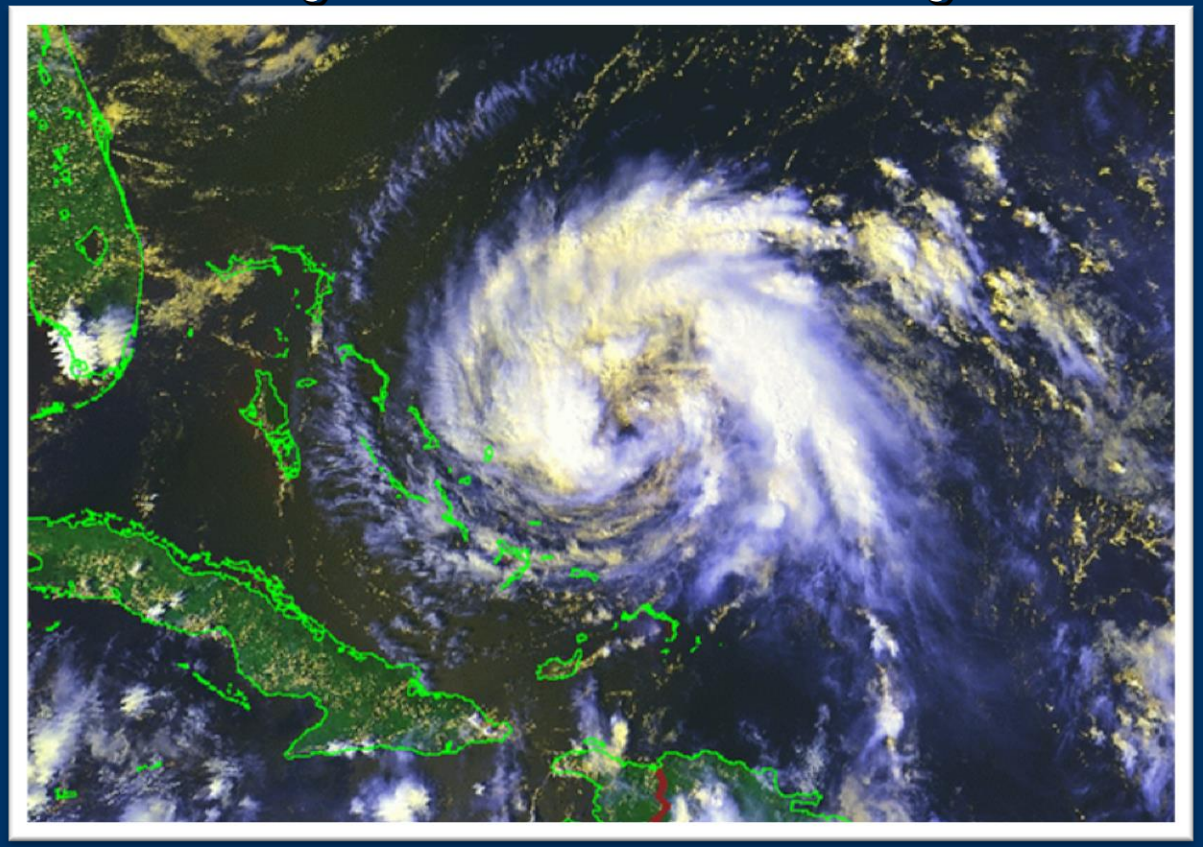
- sustained winds less than 39 mph
- surface low pressure better organized



Tropical Cyclone Stages

Tropical Storm

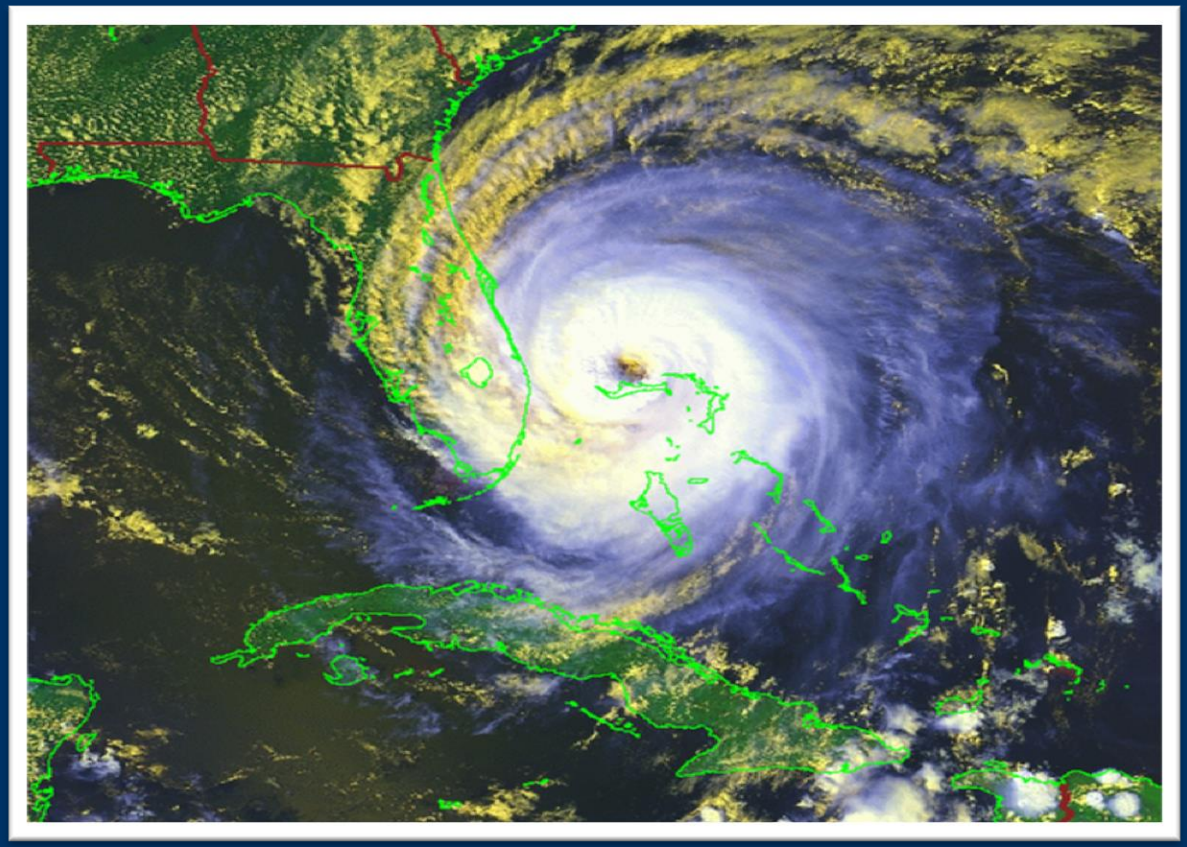
- sustained winds of 39-73 mph
- more organization of thunderstorms around the center
- gets a name at this stage



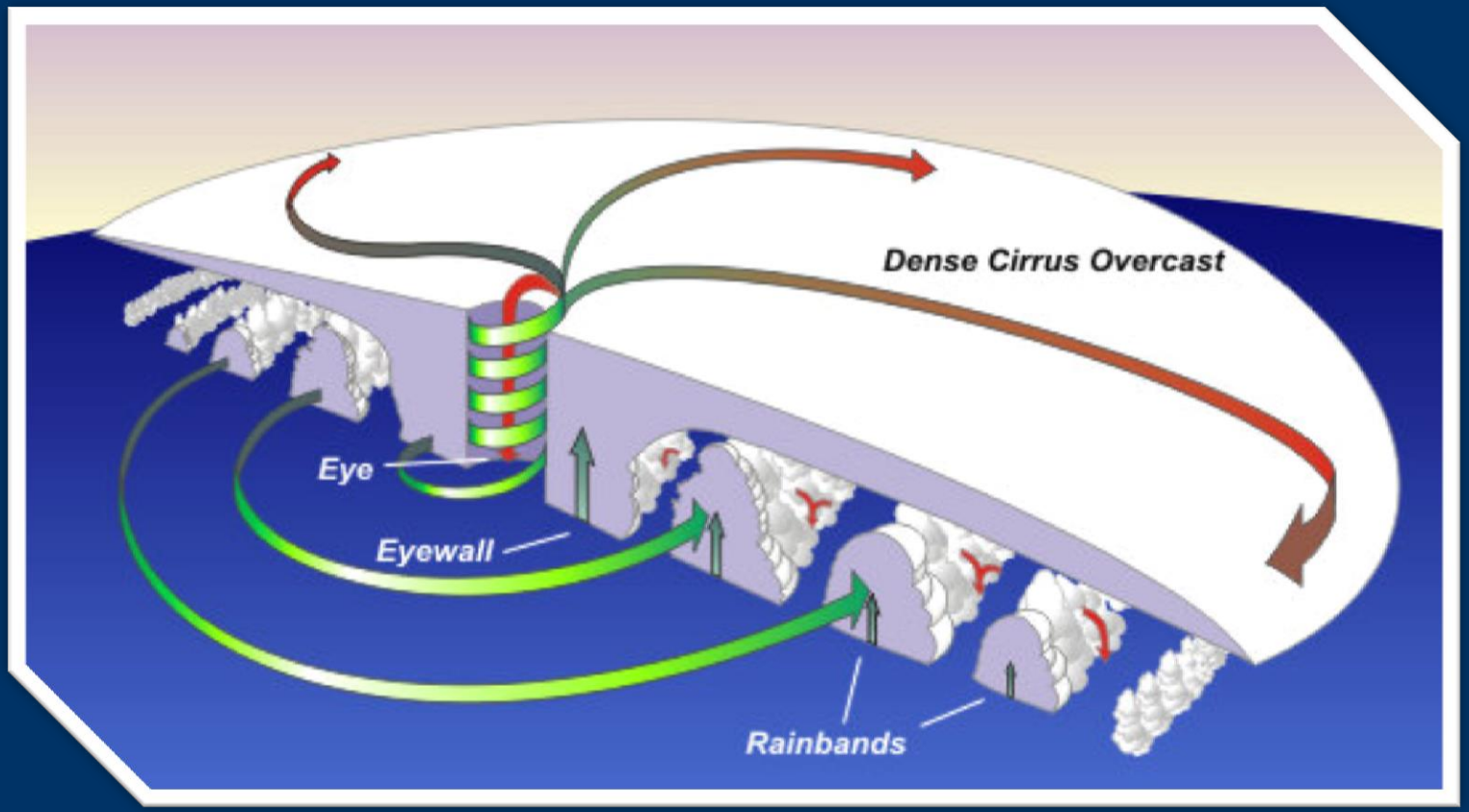
Tropical Cyclone Stages

Hurricane

- sustained winds of 74 mph or greater
- very well-organized system with thunderstorms around the central "eye" as well as in rain bands spiraling inward toward the center



Hurricane Structure



- The eye wall surrounds the calm eye and typically contains the strongest winds
- The outer rain bands contain gusty winds, heavy rain and some tornadoes

Saffir-Simpson Hurricane Wind Scale

- Category 1:
  - 74-95 mph winds
  - minimal damage
- Category 2:
  - 96-110 mph winds
  - moderate damage
- Category 3:
  - 111-129 mph winds
  - major damage
- Category 4:
  - 130-156 mph winds
  - extreme damage
- Category 5:
  - 157+ mph winds
  - catastrophic damage

- http://hurricanes.gov/aboutsshws.php

Major hurricanes (Cat 3-5) produce 85% of all hurricane damage!

Note: This scale should NOT be used to determine the amount of storm surge a hurricane can produce!!

Hurricane Observing & Forecasting

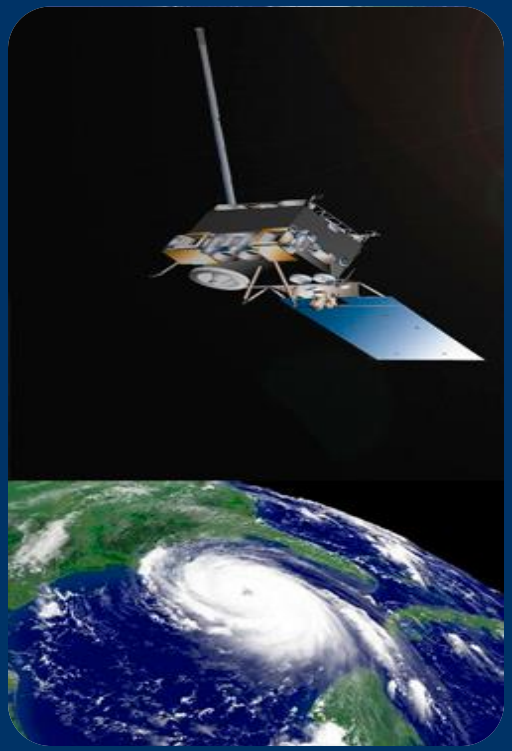
Aircraft – "Hurricane Hunters"

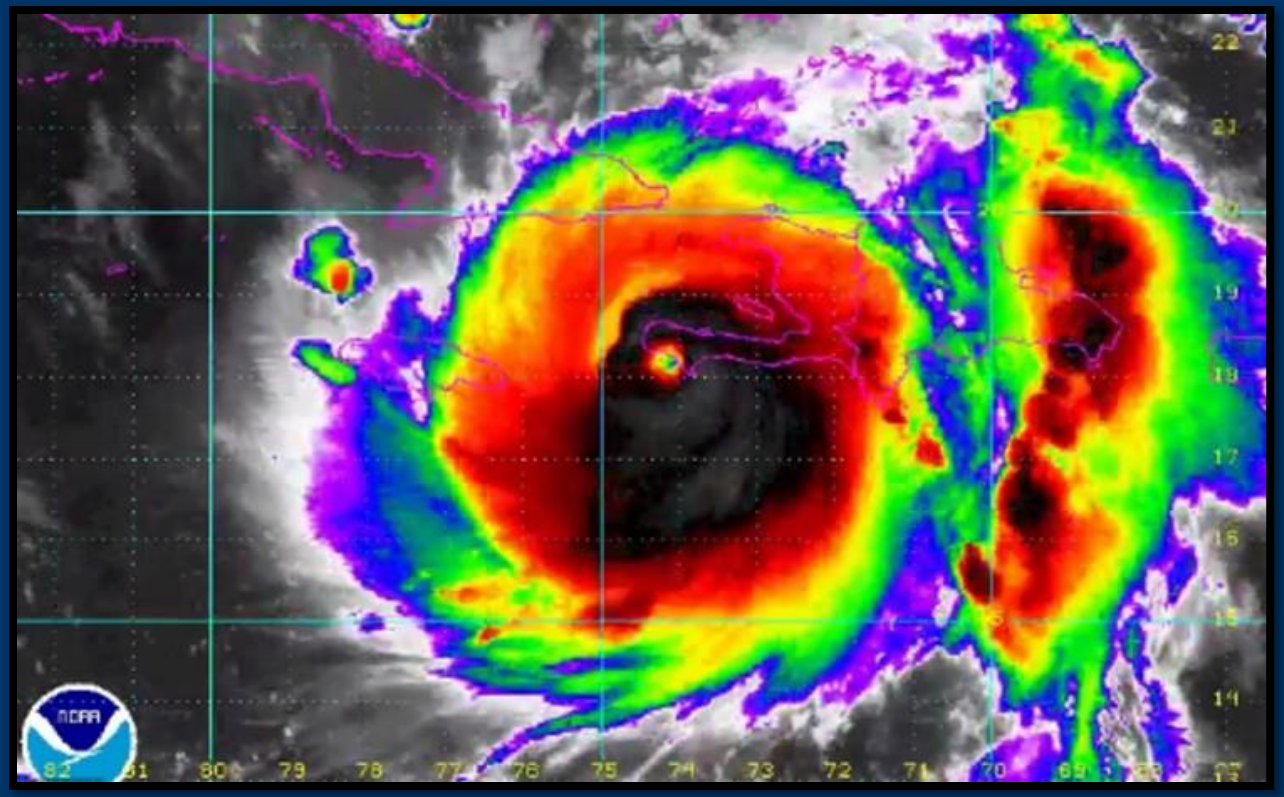
- NOAA P-3/Air Force Reserve WC-130
  - samples storm environment between 500 – 10,000 feet
- NOAA Gulf Stream IV
  - samples a large area around storm ~45,000 feet high

Hurricane Observing & Forecasting

Satellites

- Global Network of Geostationary and Polar Orbiters
  - used for hurricane analysis, tracking and forecasting

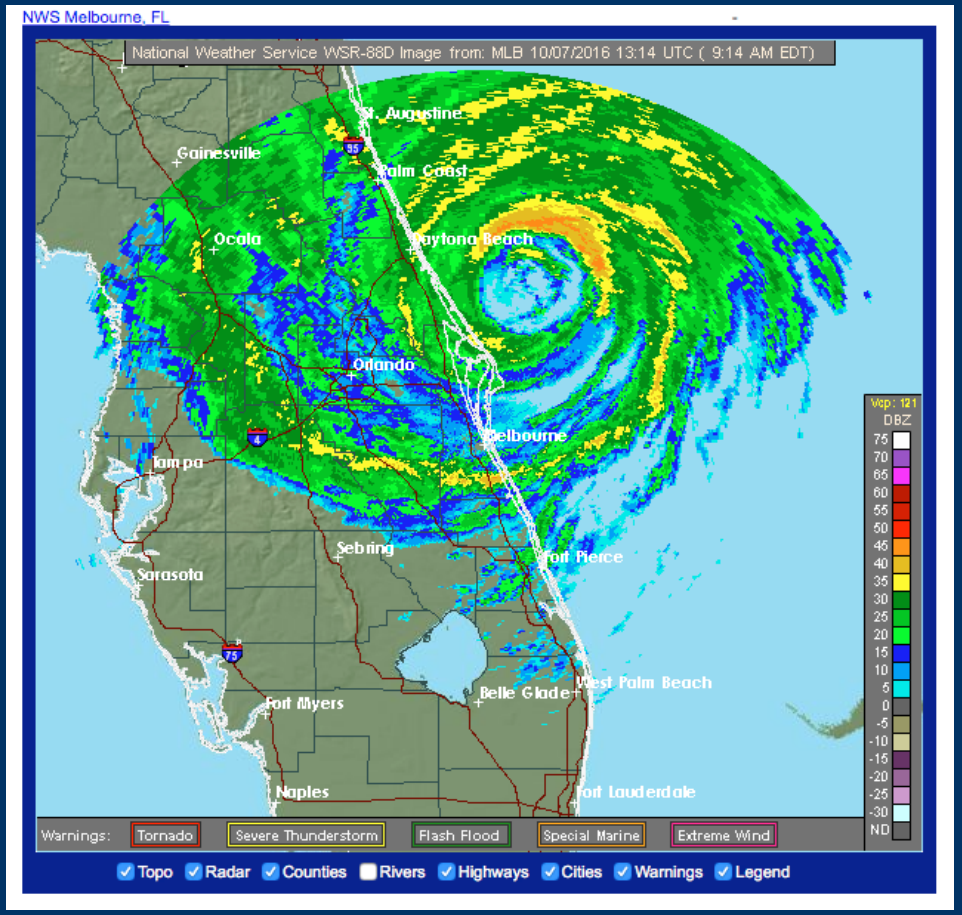




Hurricane Observing & Forecasting

NWS Doppler Radar

- observes winds and tornadoes and helps locate the center of the storm



Hurricane Observing & Forecasting

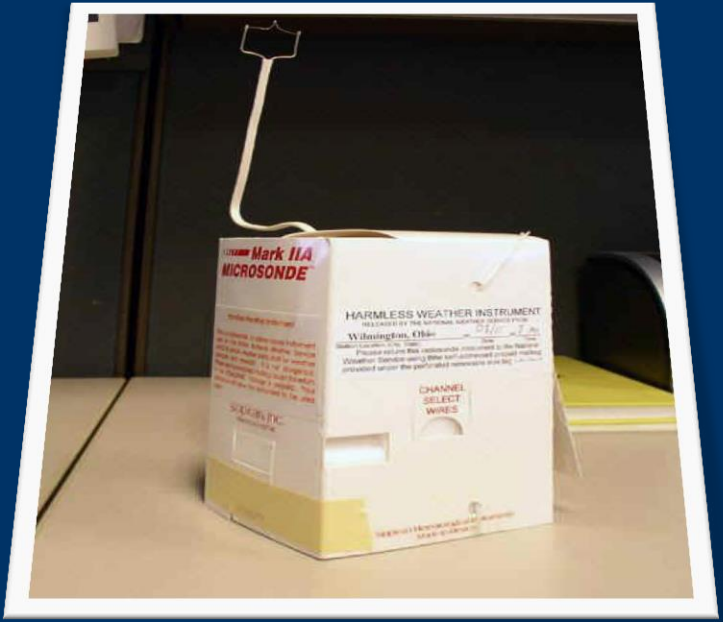
Buoys, Ships, & Land-based Observations

- observe pressure, winds, and waves

Hurricane Observing & Forecasting

Weather Balloons/Radiosondes

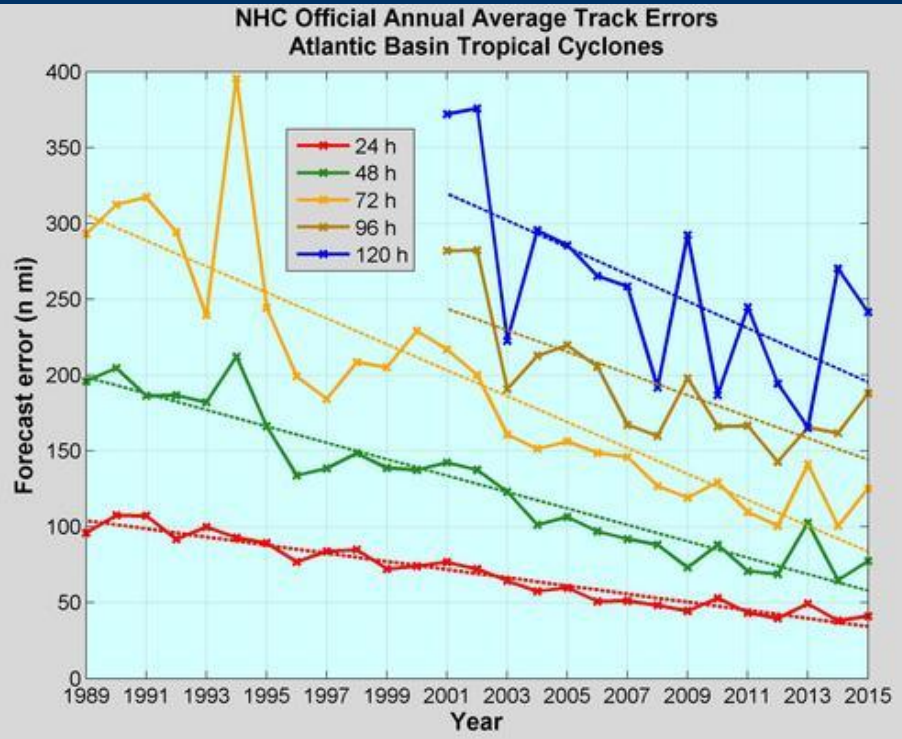
- launched up to 4 times per day during hurricanes
- observe pressure, temperature, winds and humidity up to around 19 miles high
- help initialize weather forecast models

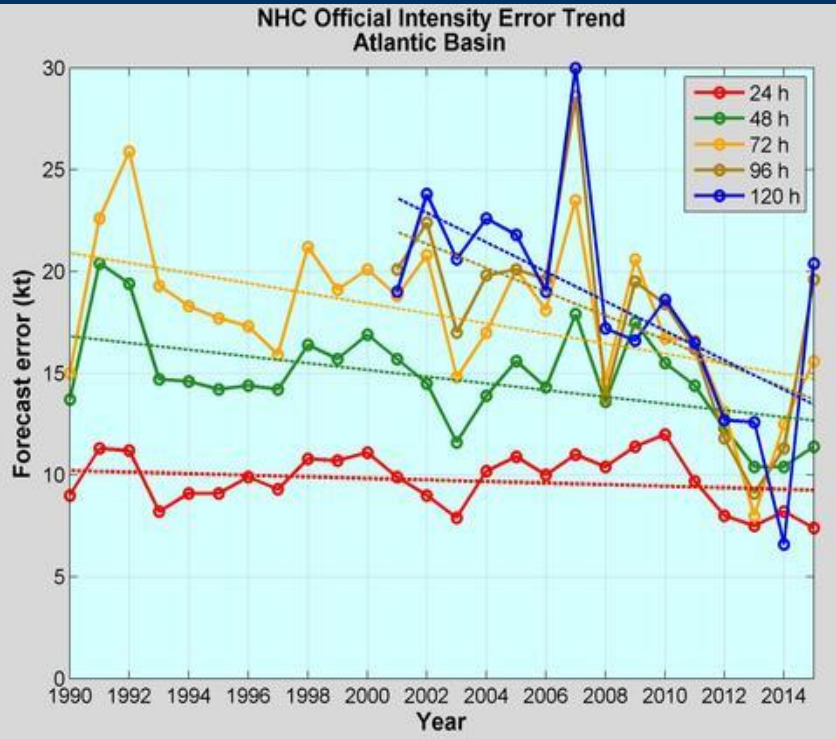


Hurricane Observing & Forecasting

Forecast Models (Dynamical and Statistical)

- There are many models used by the National Hurricane Center in their forecasts of a storm's track & strength
- As shown below, NHC's official forecasts have generally been improving over the last several decades (especially the track forecasts)





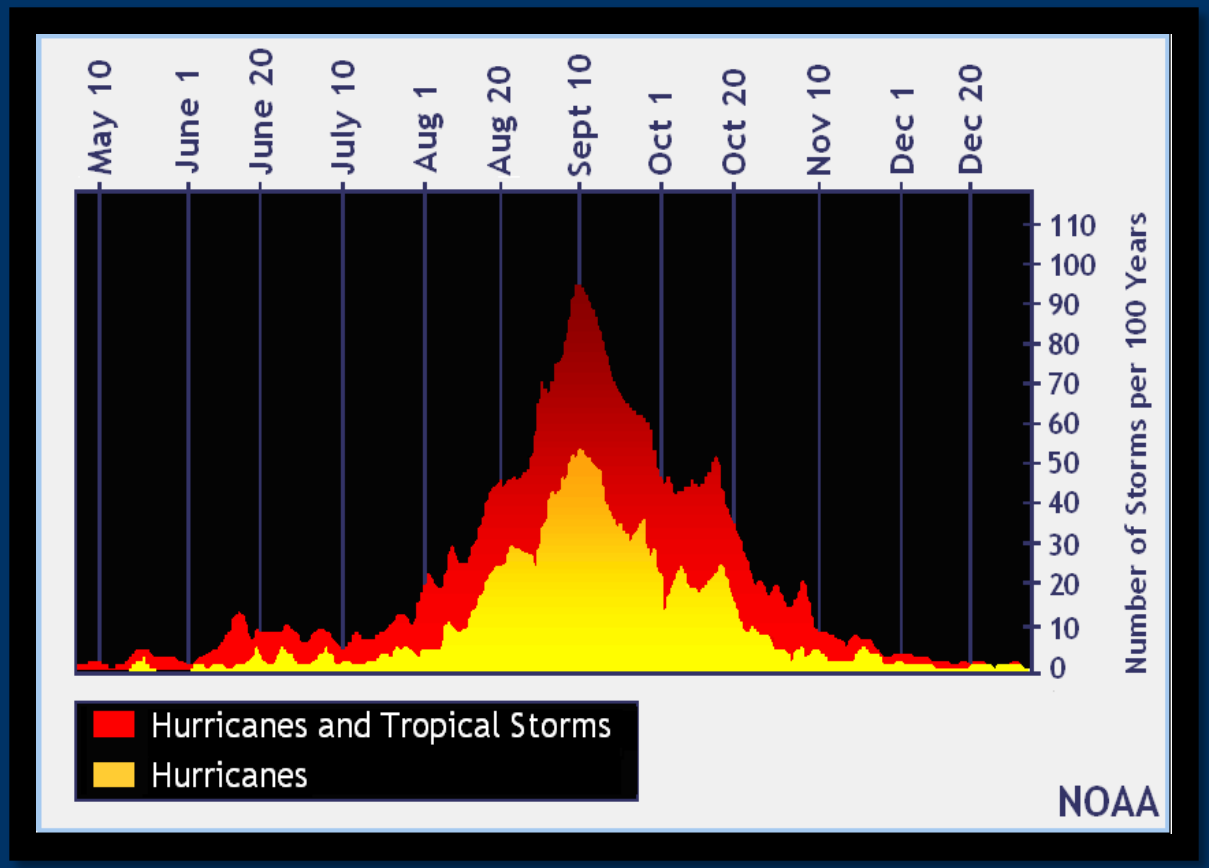
Outline

- ~~Tropical Cyclone Hazards~~
- ~~Being Prepared and Staying Informed~~
- ~~Tropical Cyclone Basics~~
- **Tropical Cyclone Climatology**
- Tropical Cyclone History for Southeast South Carolina and Southeast Georgia

Atlantic Basin Hurricane Season

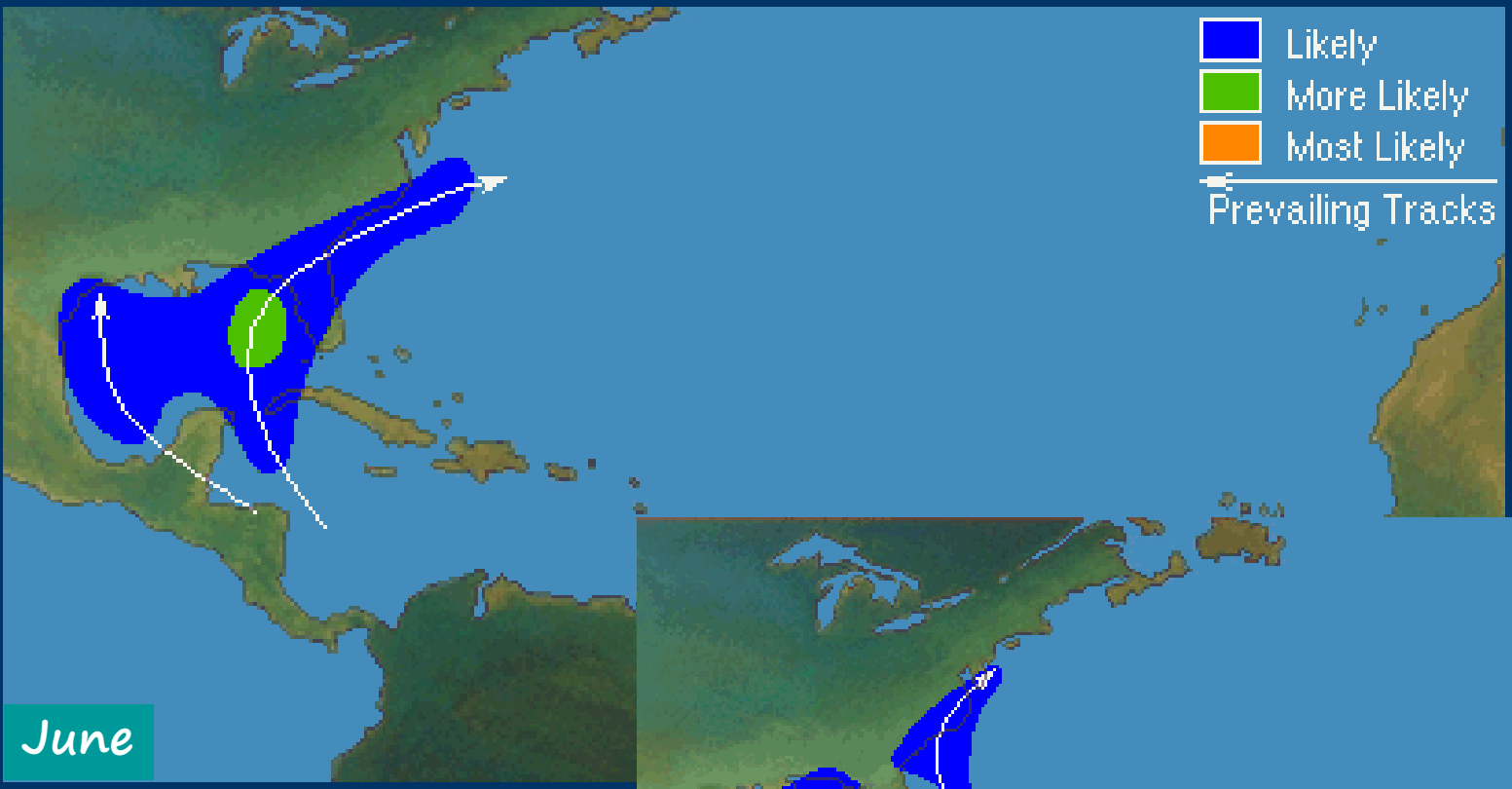
June 1 – November 30

- Atlantic basin includes most of northwest Atlantic Ocean, Caribbean Sea and Gulf of Mexico
- The peak of the season is around September 10
- However, tropical cyclones can occur before June and after November if the conditions are right

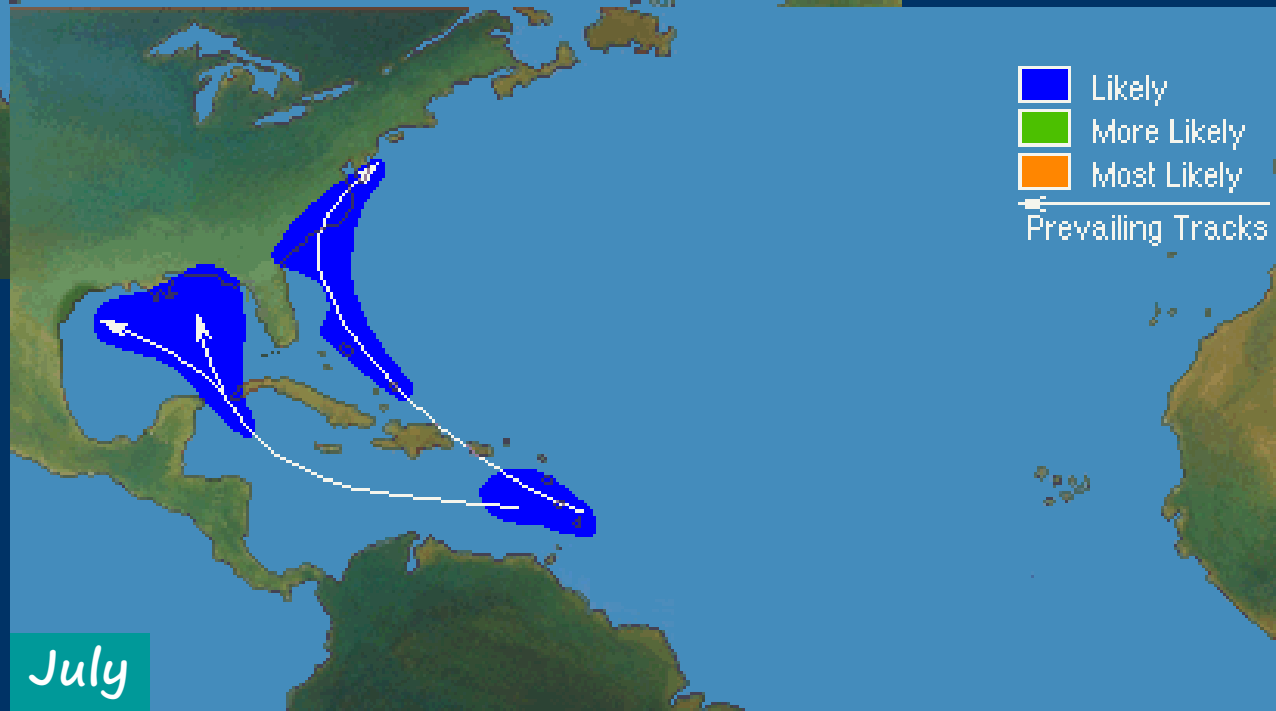


» *Image courtesy of NWS/National Hurricane Center*

Typical Hurricane Formation Areas/Tracks



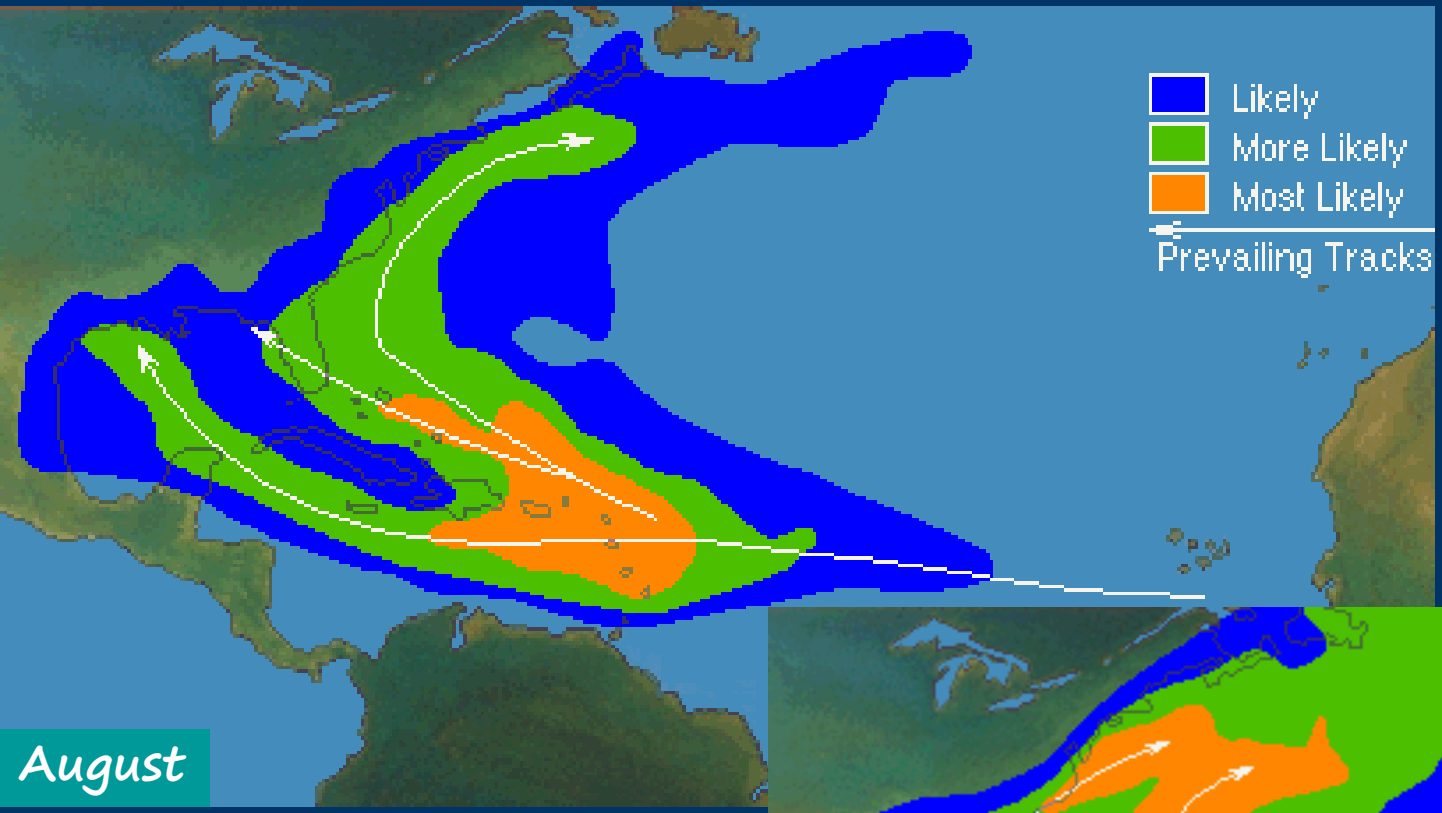
June



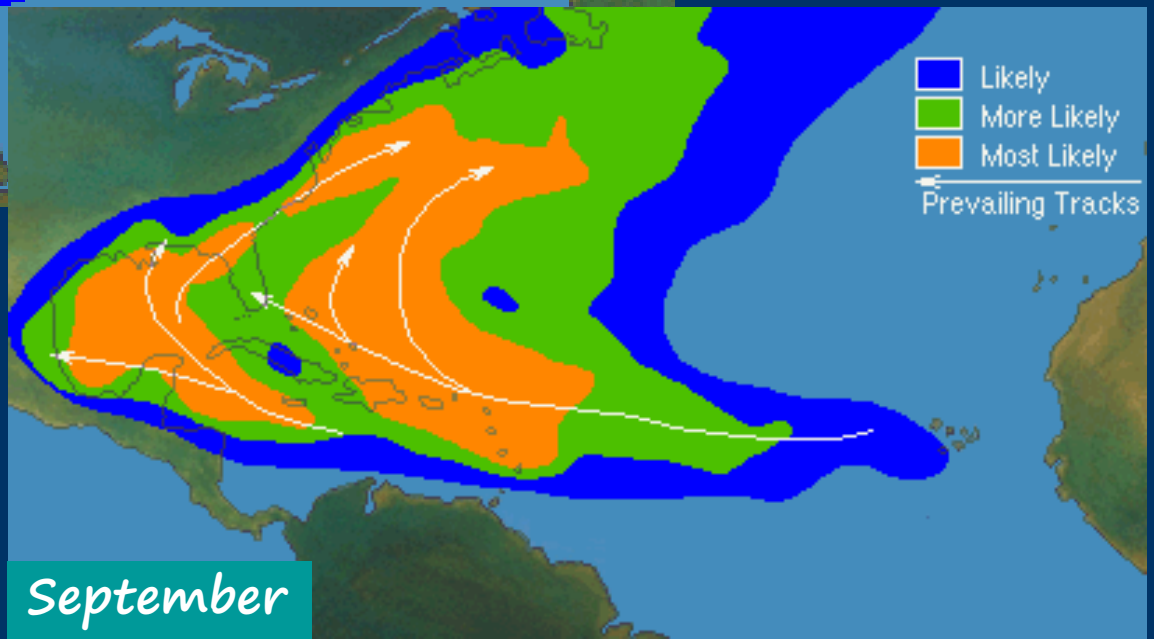
July

» *Images courtesy of NWS/NHC*

Typical Hurricane Formation Areas/Tracks



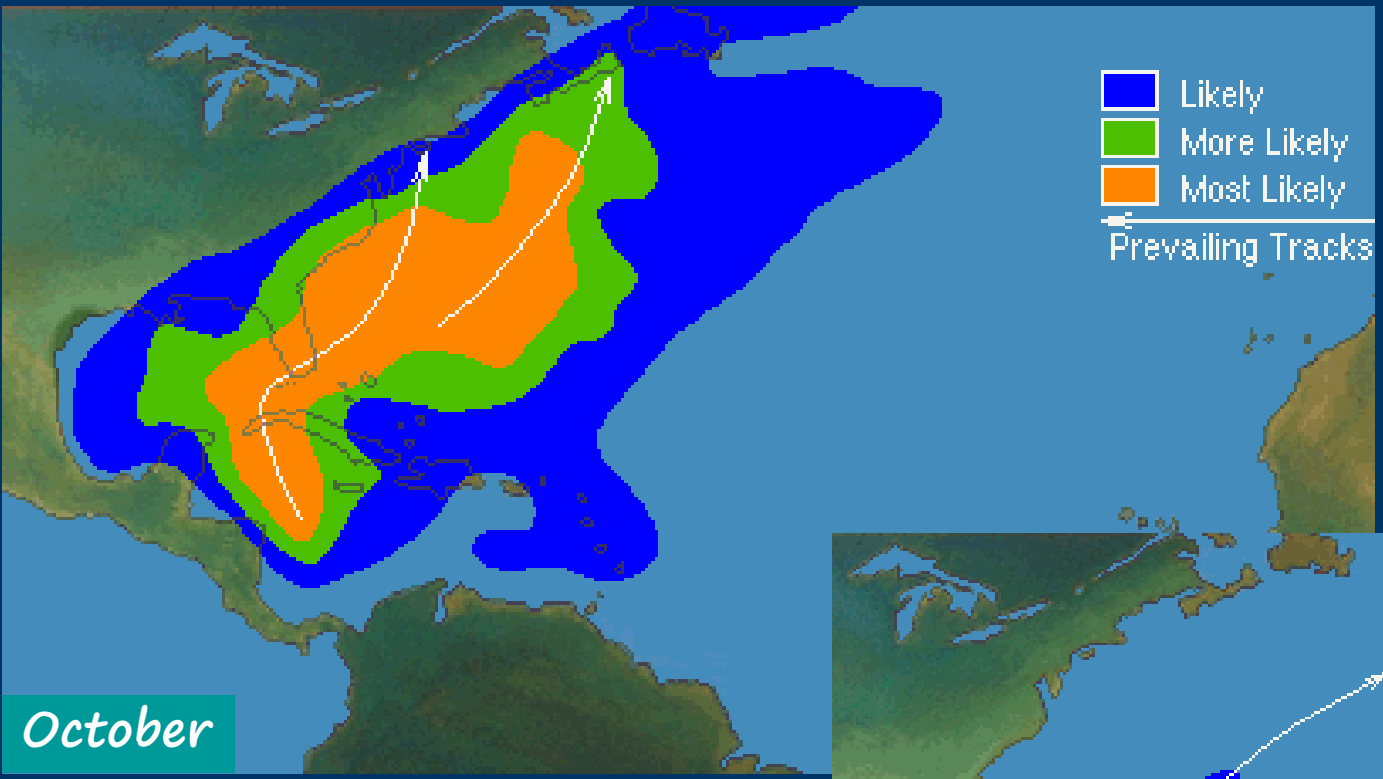
August



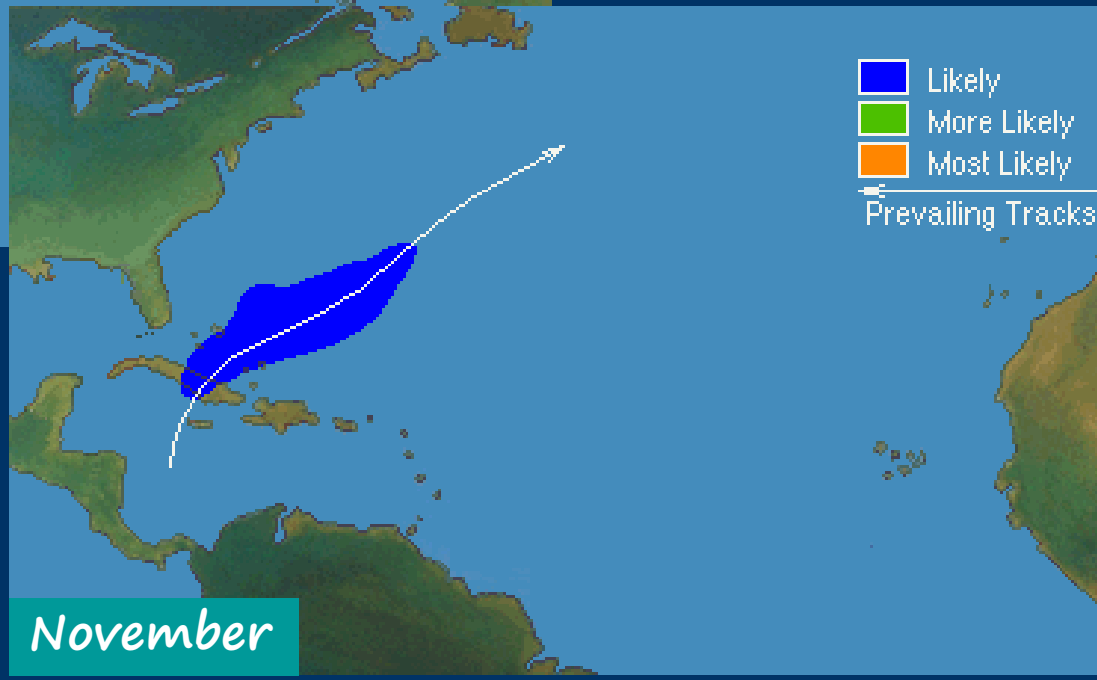
September

» *Images courtesy of NWS/NHC*

Typical Hurricane Formation Areas/Tracks



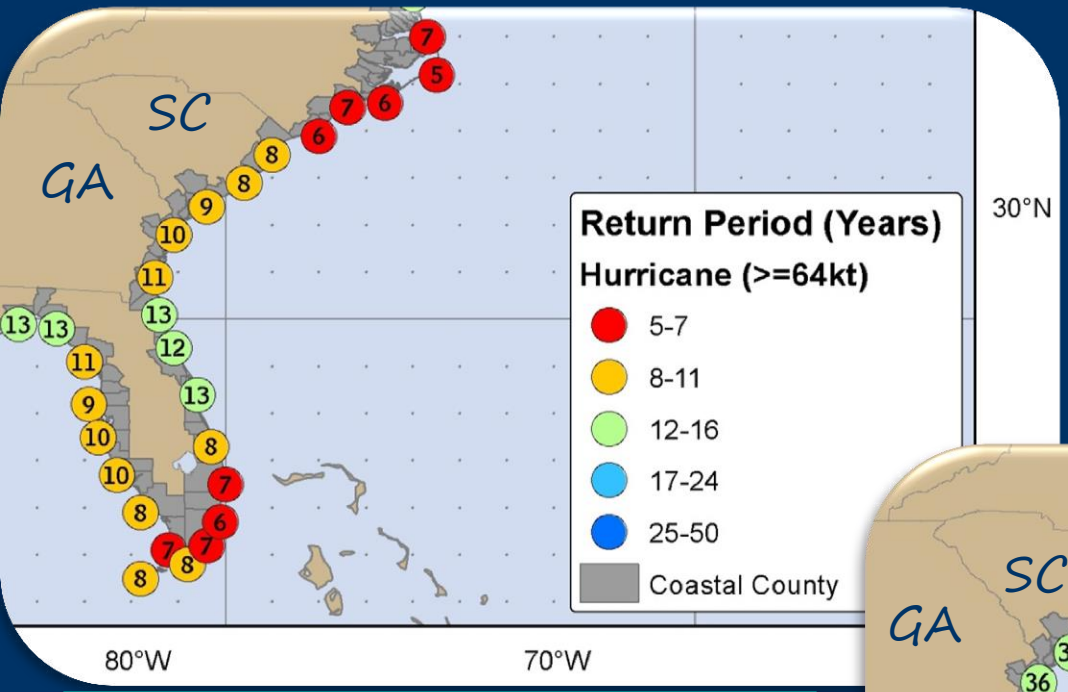
October



November

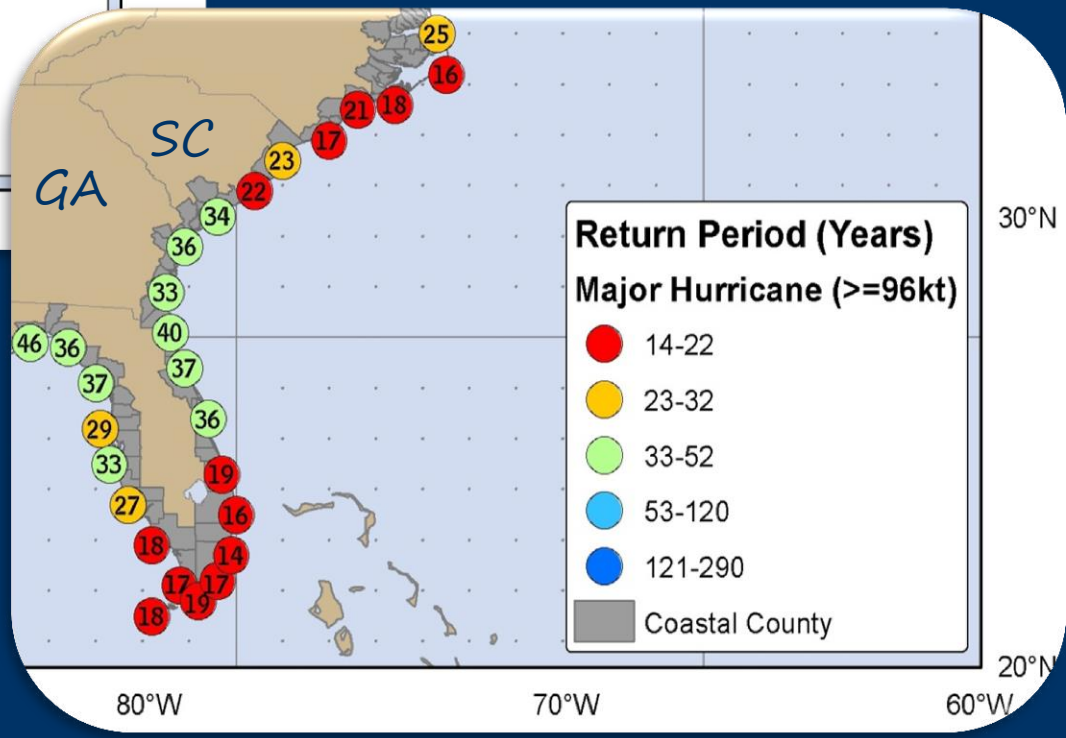
» *Images courtesy of NWS/NHC*

Southeast U.S. Hurricane Return Periods



- **Return Period**: frequency of a particular event

On **average**, a hurricane passes within 50 nm of Charleston (Savannah) every 8 (10) years with a major hurricane doing so at Charleston (Savannah) every 22 (36) years



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Local Tropical Cyclone History

http://weather.gov/chs/TChistory

- Since official records began in 1851, 41 tropical cyclones (tropical depressions, tropical storms and hurricanes) have made landfall in the NWS Charleston County Warning Area (Charleston Co, SC south to McIntosh Co, GA), including:
  - 6 tropical depressions
  - 10 tropical storms
  - 25 hurricanes, 5 of which were Cat 3-5, including:
    - Unnamed - Sep 1854
    - "Great Sea Islands Hurricane" - Aug 1893
    - Unnamed - Oct 1893
    - Gracie - Sep 1959
    - Hugo - Sep 1989

» Images courtesy of NOAA

Important Links

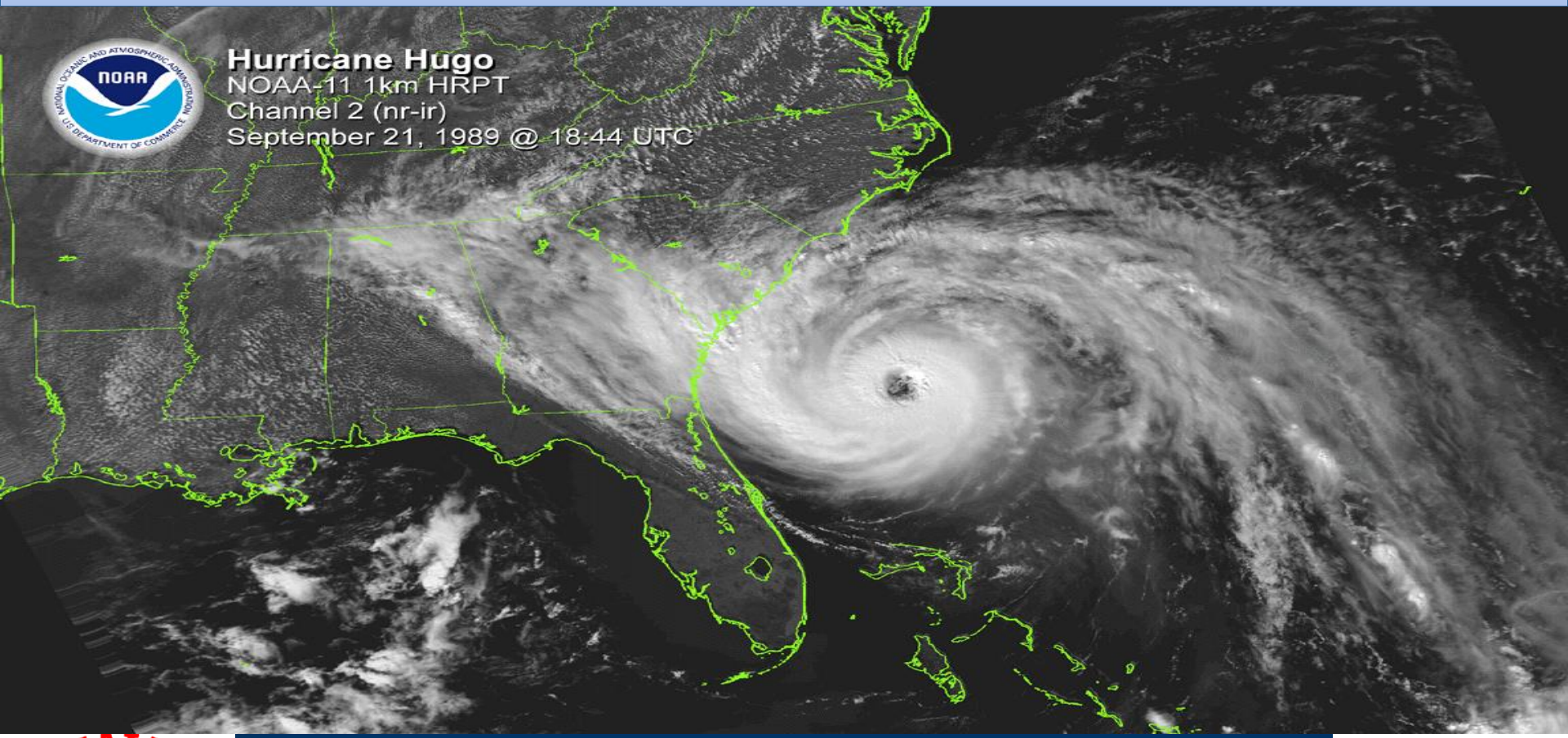
- **Hurricane Safety/Preparedness**
  - National Weather Service:
    - http://weather.gov/om/hurricane/index.shtml
  - NWS National Hurricane Center:
    - http://hurricanes.gov/prepare
  - Federal Emergency Management Agency:
    - http://www.fema.gov
  - Department of Homeland Security:
    - http://www.ready.gov/hurricanes
  - South Carolina Emergency Management (includes evacuation zone/route info): http://www.scemd.org/
  - Georgia Emergency Management (includes evacuation zone/route info): http://www.gema.ga.gov/

- **Tropical Cyclone Forecasts**
  - NHC: http://hurricanes.gov
  - NWS Charleston, SC: http://weather.gov/chs/tropical

Important Links

- Storm Surge
  - NHC: http://hurricanes.gov/surge
  - Risk Maps: http://hurricanes.gov/nationalsurge/
- Southeast SC/GA Tropical Cyclone History
  - http://weather.gov/chs/TChistory
- Tropical Cyclone Frequently Asked Questions (FAQ)
  - http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html
- NOAA Education Resources – Hurricanes
  - http://www.noaa.gov/resource-collections/hurricanes
- Tropical Cyclone Names
  - http://hurricanes.gov/aboutnames.shtml

We Wish You a Safe Hurricane Season!



http://weather.gov/chs

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